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BRIDGE MANUAL

CONTAINING

STANDARDS, GENERAL INFORMATION AND INSTRUCTIONS

BULLETIN No. 3

OFFICE OF THE
STATE HIGHWAY COMMISSION
SALEM, OREGON
DECEMBER, 1916

Prepared under the direction of
JOHN H. LEWIS, State Engineer

CONCRETE VIADUCT—360 FEET LONG

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INTRODUCTION

The State Engineer is required by law to assist County Courts in all matters pertaining to the construction, maintenance and repair of bridges and culverts, upon request.

This manual has been prepared, not only to more fully comply with this provision of the law, but also for distribution to the various county roadmasters, surveyors, supervisors, and others in authority, in an endeavor to standardize somewhat the practice throughout the State in the construction of bridges and culverts.

Changing traffic conditions within the last few years have forced upon us the adoption of new standards of design and construction. Some county authorities are still following the old standards, which are not suited to modern requirements, while others are going to extremes in the other direction.

This manual should assist in bringing about a greater degree of uniformity in the practice of the various counties in this regard, and assist authorities in anticipating, in a reasonable and conservative way, the increasingly heavy loadings, and frequency of use which bridges erected during the next few years will be called upon to sustain.

Many requests have been made to the department for information as to standards, and practice now being followed. In endeavoring to more fully supply this want, the department will make it possible for constructive criticism to be offered, so that future editions and practice can be an improvement. The department will therefore welcome any suggestions to this end.

A similar manual, describing the "Account Number" system for keeping total and unit costs of the various features of the work, will soon be issued. This will enable the various counties to install and follow the same system, if desired. Several counties have already made inquiry concerning this system, and a few have adopted it for special jobs.

To standardize methods of making surveys for highways, a manual on field and office practice is now in preparation. Few, if any, surveys by county surveyors are sufficiently complete to be used by the State in checking up the location and letting contracts for construction work thereon. The standardization of this branch of the road work would result in a considerable saving of both time and money.

I am indebted to Joseph Weare, assistant engineer in charge of the bridge department, for the compilation of the data in this manual under my general direction; L. W. Metzger is largely responsible for the details of design, and Charles C. Durkee for the drawings from which the various cuts were prepared.

JOHN H. LEWIS, State Engineer.

SERVICES AVAILABLE TO COUNTIES

PLANS AND SPECIFICATIONS FREE

The State Highway Department is required by law to furnish, **free of charge**, on request from the counties, plans and specifications for highway bridges and culverts on county roads.

ESTIMATES AND APPROVAL OF PLANS

The department will, on request, advise with County Courts as to the suitability of bridge plans drawn up by others than the Highway Department to meet the proper requirements of location, span, foundation, clearance, loadings and design, and at the option of the court will either furnish estimates of the structures or supply to the court data upon which such estimates can be based.

SUPERVISION

It will, if desired, supervise the construction of bridges, drawn up either on its own plans or by others, thus insuring materials and workmanship substantially as agreed upon in the contract. The cost of the regular inspector employed on the work to be paid by the county.

AID IN SECURING BIDS

Work done under the supervision of the department is going on continuously and it is often in a position, through knowledge of various contractors scattered over the State and through acquaintance with material prices and supplies, to assist in securing for the counties, if requested, wider competition in the lettings of any proposed structure.

INSPECTIONS

Inspections of existing structures are being constantly made by engineers of the department at the request of counties throughout the State, and recommendations are made, either as to repairs to present bridges or replacement by new ones.

ORGANIZATION OFFERED

An organization of technical bridge men is employed who make a specialty of this work. Due to the many standard plans and specifications already on file in the department, it is able to get out quickly, at small expense to the State and no expense to the county, plans and specifications which if not so prepared would call not only for time on the part of the county official, which he otherwise would have free for road matters proper, but for an experience in strictly bridge matters which he does not often claim to possess.

RECORD OF WORK

The Bridge Department has, in the three years since its organization in 1913, drawn up plans and specifications for 93 bridges, whose estimated cost is over $630,000. Of these designs, bridges to a value of more than $370,000 have been constructed.

LAWS GOVERNING STATE AID TO COUNTIES

BRIDGES AND CULVERTS

The Engineer (meaning the State Engineer) by provision of Laws 1915, Chap. 337, p. 537, shall compile statistics relative to public highways throughout the State and collect all information in respect thereto which he may deem important.—Laws 1913, Chap. 339, p. 664.

He shall collect information and compile statistics relative to mileage, character and conditions of highways and bridges in the different counties of the state.—Laws 1913, Chap. 339, p. 664.

The County Court of any county and all other officers of any county having the care and supervision of public highways and bridges, shall from time to time on written request from the State Engineer, furnish him with all available information in connection with the building and maintenance of public highways, culverts and bridges in their respective localities.—Laws 1913, Chap. 339, p. 665.

Said Engineer may be consulted at all reasonable times by the county officers having care and authority over highways, culverts and bridges, and shall advise such officers relative to the construction, repair, alteration or maintenance of same, and shall furnish such other information and advice as may be requested by persons interested in the construction or maintenance of public highways.—Laws 1913, Chap. 339, p. 664.

Said Engineer shall at all times lend his aid in encouraging and promoting highway improvements throughout the State.—Laws 1913, Chap. 339, p. 664.

Upon request of the County Court of any county, said Engineer shall furnish specifications for any piece of proposed road construction in such county upon being furnished the necessary data and information, and such specifications shall be furnished free of all costs to such county.—Laws 1913, Chap. 339, p. 664.

STATUTES COVERING CONSTRUCTION

The following three sections of the State law are among the most important of those governing the necessary steps in the construction of a bridge under the statutes.

They are quoted verbatim, with the exception that headings are introduced to point out and make clear the outstanding features of the subject.

CONTRACT FOR BRIDGE COSTING OVER $500.00

BRIDGE LETTING TO BE ADVERTISED

Whenever any bridge is to be built by any county in this State, the estimated cost of which shall exceed the sum of $500.00, the county court shall at once advertise for sealed bids, according to the plans, specifications, and strain diagrams, to be prepared under direction of the county court, to be kept on file in the office of the county clerk, for the information of bidders.

METHOD OF ADVERTISING

Said advertisement to be published for at least three consecutive weeks in the official newspaper of the county, if a weekly, and twenty days, if a daily paper;

COUNTY COURT TO PREPARE ESTIMATE

* * * provided, however, that the county court shall prepare an estimate of the probable total cost of said bridge, which said estimate shall become public property only after final action shall have been taken on the bids submitted.

BIDDERS TO GIVE BOND

Each bidder shall be required to deposit with his bid five per cent of the amount of his bid, which shall be forfeited to the county in case the award is made to him, if the fails, neglects, or refuses, for a period of ten days after such award is made, to enter into the contract and file his bond in the manner required by and to the satisfaction of the county court. * * *

CONTRACT AWARDED UPON COMPETITIVE BIDS

* * * Upon the day appointed, the county court shall proceed to open bids and award the contract to build such bridge to the lowest responsible bidder, and the county court shall enter into contract with him therefor; * * *

REJECTION OF AND RE-ADVERTISEMENT FOR BIDS

* * * provided, always, that said county court may, in its discretion, reject any and all bids; and provided further, that said county court, in its discretion, may re-advertise for bids from time to time in like manner; and in its discretion may reject any and all bids; * * *

COUNTY MAY CONSTRUCT BY FORCE ACCOUNT

* * * and provided further, that said county court, after having rejected all bids, in its discretion may employ a suitable superintendent and assistants; procure the necessary material and cause said bridge to be constructed. And, in that event, said superintendent shall inspect all material as to its fitness, and shall inspect all bills for material and labor and shall certify to their correctness before they shall be ordered paid by said court;

COST OF SUCH WORK TO BE FILED WITH CLERK

and immediately upon the completion of said bridge, shall prepare and file with the clerk of said court a full, true and complete statement, duly verified by his oath, giving the name of the stream across which said bridge is built, the name or location of said bridge suitable for identification, its entire length, width, amount and cost of each kind of material and labor and the entire cost of said bridge, with a brief general description of the style and character thereof, and of its immediate surroundings, which statement shall be subject to inspection at all times by any person.

LOWEST RESPONSIBLE BID AND FORCE ACCOUNT TO BE PUBLISHED TOGETHER

And immediately upon the filing of said statement, said county court shall cause to be published at least one time in said paper a statement giving the total cost of said bridge and the lowest responsible bid received for the building of said bridge, and the estimate of the probable total cost.—Laws 1915, Chap. 173, Sec. 1, p. 210.

CONTRACTORS' BONDS ON PUBLIC WORKS TO CONTAIN CLAUSE TO PAY LABOR AND MATERIAL

PENAL BOND REQUIRED

Hereafter any person or persons, firm or corporation, entering into a formal contract with the State of Oregon, or any municipality, county, or school district within said State, for the construction of any buildings, or the prosecution and completion of any work, or for repairs upon any building or work, shall be required before commencing such work, to execute the usual penal bond with good and sufficient sureties, with the additional obligations that such contractor or contractors shall promptly make payments to all persons supplying him or them labor or materials for any prosecution of the work provided for in such contracts; * * *

SUITS FOR LABOR AND MATERIAL ACCOUNTS TO BE BROUGHT IN NAME OF STATE, COUNTY, ETC.

* * * and any person or persons making application therefor, and furnishing affidavit to the proper officer of such State, county, municipality, or school district, under the direction of whom said work is being or has been prosecuted, that labor or materials for the prosecution of such work has been supplied by him or them, and payment for the same has not been made, shall be furnished with a certified copy of said contract and bond, upon which said person or persons supplying such labor or materials shall have a right of action, and shall be authorized to bring suit in the name of the State of Oregon, or any county, municipality, or school district within such State for his or their use and benefit against said contractor and sureties, and to prosecute the same to final judgment and execution; * * *

PUBLIC OFFICIALS JOINTLY LIABLE FOR FAILURE TO EXACT BONDS

* * * provided, that in case the contractor shall fail to pay for such work and materials, and said officers of the State of Oregon, or any such municipality, county, or school district within said State, shall fail or neglect to require the persons, firm, or corporation entering into such contract, to execute such bond, then and in that event, if such contract shall have been entered into with the State of Oregon, the State of Oregon and the officers authorizing such contract shall be jointly liable for the labor and materials used in the prosecution of any work thereunder, or in case such contracts shall have been entered into on behalf of any municipality, county, or school district within the State of Oregon, then and in that event, such municipality, county, or school district and the officers authorizing such contract shall be jointly liable for such labor and materials to the persons performing such labor and the persons furnishing such materials.—Laws 1913, Chap. 27, p. 59.

Limitations of This Statute—The effectiveness of this statute is limited inasmuch as it fails to extend the responsibility of officials who fail to exact bonds, to include damage or loss of the structure while in process of erection. The contractor's own resources are then the only guarantee against the loss of public funds in case such bonds have not been secured. The law should be remedied in this respect.

PROCEEDINGS FOR BRIDGE OVER STREAMS, BOUNDARY BETWEEN COUNTIES

COUNTIES AUTHORIZED TO UNITE

Whenever it shall be deemed necessary by the county court of any county in the State of Oregon to erect, construct or repair a bridge over any stream which is a boundary line between two counties, the county courts of the said adjoining counties of which the said stream is a boundary line, are hereby authorized to unite for the purpose of erecting, constructing or repairing such bridge,

INITIAL STEPS

and when any person or persons interested shall apply in writing to the county court of either of the said counties of which the said river is a boundary, the court may proceed to appoint three viewers who shall, after being first duly sworn to well and faithfully perform their duties as such viewers, proceed to view the bridge proposed to be repaired or the site designated by the said county court for the erection and construction of such new bridge, and make an estimate of the cost of such repairs or the erection and construction of such new bridge, and make a report of their proceedings to the said court together with a statement of the proposed repairs or with the plans and specifications of such new bridge to be erected.

ACTION BY COUNTY INITIATING MOVEMENT

If the court shall decide to appropriate one-half or more of the amount necessary for such repairs, or for the erection and construction of such new bridge, it shall submit such estimates of the cost, together with the statement of repairs or with the plans and specificaions of the new bridge so to be erected, to the county court of the other county to which the said stream is a boundary line,

ACTION BY SECOND COUNTY ON REPORT OF FIRST

and if the county court of such county shall approve such estimate of cost and the statement of repairs or plans or specifications of such new bridge to be erected, and shall further agree to defray one-half or less of the whole sum necessary to the completion of such repairs or the erection and construction of such new bridge together with one-half of the necessary cost of the view, then the county court to which application was first made, shall proceed to appoint a superintendent to repair in accordance with the said statement of repairs, or to erect and construct the said bridge in accordance with the said plans and specifications and as provided in Section 6366, Lord's Oregon Laws.

DIVISION OF EXPENSE

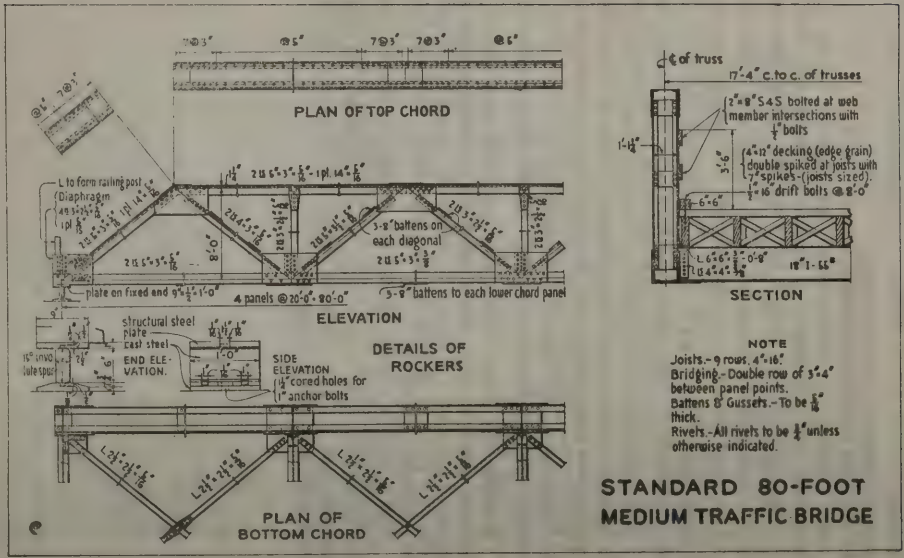
Any portion of the whole cost and expense agreed upon shall be a legal claim against each of the counties party thereto;

FIRST COUNTY MAY PAY ALL IF SECOND COUNTY ACCEPTS PLANS

provided, however, that if the said court to which is submitted such statement of repairs or plans and specifications of such new bridge to be erected, shall approve the same and consent to the making of said repairs or to the erection and construction of such bridge, but refuse to pay any part thereof as herein provided, the county court to whom application was first made may proceed to appoint a superintendent to make the said repairs in accordance with the statement, or erect and construct such new bridge in accordance with the plans and specifications thereof, and in accordance with Section 53 of this Chapter [6368, L. O. L.], in which case the whole cost and expense of such repairs or erection and construction and the maintenance thereof, shall be paid by the county so repairing or erecting and constructing such bridge or causing the repair to be made or the erection and construction thereof. [Laws 1915, Chap. 82, Sec. 1, pp. 89-90.]

Remarks—It should be noted in connection with this law for intercounty bridges that there is no provision against a deadlock between the counties, either as to acceptance of proposed plans or division of the cost equitably among the two counties concerned.

This status of affairs should be remedied so that where either county shows a willingness to undertake its reasonable and legitimate share toward an improvement needed by both counties and by the State at large, the necessary action cannot be indefinitely postponed.


PLAN OF TOP CHORD
ELEVATION
4 panels @ 20'-0" = 80'-0"
5-8" battens on each diagonal
5-8" battens to each lower chord panel
plate on fixed end
DETAILS OF ROCKERS
SIDE ELEVATION
END ELEVATION
structural steel plate cast steel
1½" cored holes for 1" anchor bolts
PLAN OF BOTTOM CHORD
℄ of truss
17'-4" c. to c. of trusses
2"x8" S4S bolted at web member intersections with ½" bolts
(4"x12" decking (edge grain) double spiked at joists with 7" spikes - (joists sized).
½"x16" drift bolts @ 8'-0"
SECTION
NOTE
Joists.- 9 rows, 4'-16".
Bridging.- Double row of 3"x4" between panel points.
Battens & Gussets.- To be ⅜" thick.
Rivets.- All rivets to be ¾" unless otherwise indicated.
STANDARD 80-FOOT
MEDIUM TRAFFIC BRIDGE

RECORDS, PLANS, SPECIFICATIONS AND COST DATA

ABSENCE OF RECORDS

One of the difficulties which confronts the State Highway Department, in the course of any investigation of existing bridges which it may be called upon to make under the law, is that plans and specifications of the structure as built cannot be found in the public records. This lack of information is particularly annoying in the case of long spans or costly structures. In most cases it is equally impossible to get cost records of the various features of the work. The public, which pays the bill, is entitled to unit and total costs of each structure, and it is suggested that special attention be given to this matter by the counties.

AID OFFERED FOR ACCOUNTING SYSTEM

Pending the adoption of some law which will introduce a road and bridge accounting system as nearly uniform as practicable throughout the State, the State Highway Department will be glad to furnish an outline of a simple and effective plan and lend the services of its auditor for the effective installation of same, if so desired.

IMPORTANCE OF FILING PLANS

Contractors should be required to furnish extra plans for the county's files, where such plans are drawn and specifications prepared by the contractor himself.

INFORMATION FOR FILES

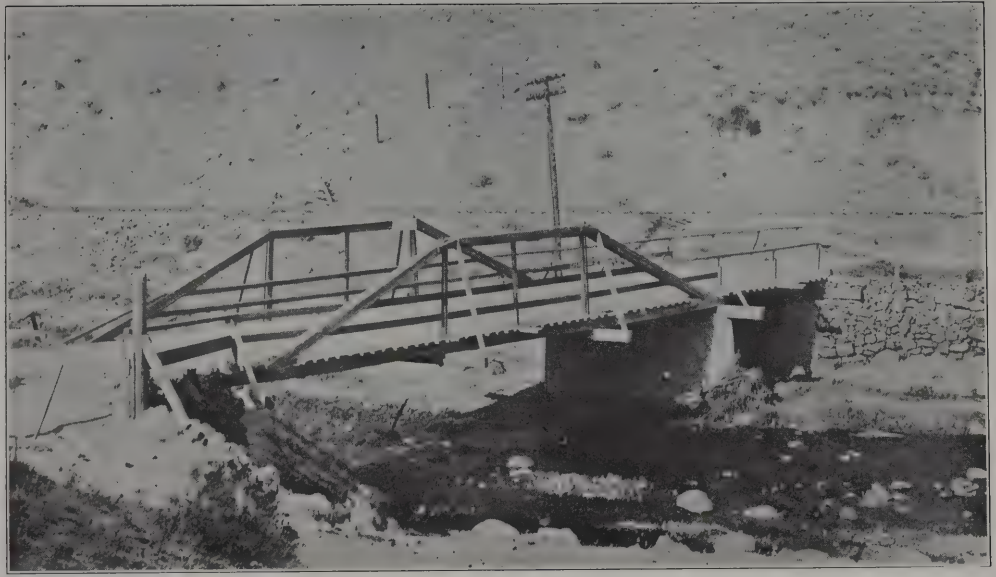
Steel Bridges—These plans should contain stress diagrams showing the loadings for which the bridge is designed; the stresses in the various members; the sizes of those members; and, if in steel, any other information necessary to checking the weight of the bridge so that not only can it be determined at any future date whether the bridge is strong enough, but also whether it is built as called for in the designs and specifications mentioned, at a reasonable price under existing conditions.

Foundations—Records should be kept on a plan and profile of the bridge site, showing the nature of the foundations of abutments and piers, and the depths to which they were actually carried; the penetration of piles, if piles were used, and, in any case, the character of the river bottom on which foundations rest. This is necessary because it is the exception rather than the rule for foundation work to be carried out exactly as shown on plans. Developments during operations often require modifications, or the difficulty of underwater work tempts the contractor to slight requirements for depth at the risk of subsequent instability or erosion. There is probably no county in the State which has not had an experience of this kind.

Concrete Bridges—Similarly, for concrete bridges, plans should show clearly the yardage of concrete; the arrangement of steel; its amount, and all details of design necessary to the determination of the strength of the bridge. At some future date, and probably not a distant one, the counties themselves will be investigating these bridges, some of which, perhaps, will be rebuilt to suit the traffic now so rapidly developing throughout the State. These records will then be invaluable. Without such plans showing the amount and location of steel, it will be impossible to determine whether or not the bridge can carry the increasing traffic.

ADVERTISEMENT, PROPOSAL, CONTRACTS AND BONDS

The questions of invitation to bidders, proposal, contracts and surety bonds meeting the requirements of the Oregon law are all of as much, if not more, importance than the specifications themselves relative to materials and workmanship. These forms are all included in the specifications used by the State Highway Department, copies of which can be had **free on application.** The text of these specifications is given in the latter part of this manual.



LONGER SPAN ELIMINATING PIER WOULD HAVE SAVED MONEY

Photo No. 1

PIERS NOT DEEP ENOUGH—UNDERMINED—PILES WILL ROT Photo No. 2

GENERAL OUTLINE AND SCOPE

The following data in regard to bridges is presented only as information for handy reference to the courts, and as a suggestion of the work in detail which is involved in the proper construction, maintenance and inspection of bridge structures. It is in no way an attempt to do more than outline the more important features of the work and suggest the various and largely technical features of the service which the State Highway Department is prepared to render.

STEPS IN BRIDGE CONSTRUCTION

The headings given indicate in a general way the various items of bridge construction which it is necessary to investigate, plan for and oversee.

The organization of the highway department is at the service of the counties in so far as it may be able to assist them in the determination of questions arising from the necessity of a proper understanding of the steps involved in the successful completion of any bridge.

SELECTING SITE OF BRIDGE

(a) Traffic.
(b) Length.
(c) Foundations.
(d) Proper approaches.

SURVEY

(a) Location of rock abutments, banks.
(b) Profile:
Surface of water.
Bottom of river.
Top of banks.
Slopes of hills.
Borings for foundation.
Flood level.
Low water.

PLANS AND SPECIFICATIONS

(a) Arrangement of spans.
(b) Type of spans.
(c) Elevation of bridge on account of floods and grades.
(d) Width.
(e) Height.
(f) Loadings.
(g) Allowance for wind.
(h) Allowance for current.
(i) Strain sheets.
(j) Design and sections.
(k) Piers.
(l) Abutments.
(m) Specifications.

LETTING OF CONTRACT

(a) Material.
(b) Current prices.
(c) Irregular and improper bids.

SUPERVISION

Foundations—
Depths, scour, obstacles, methods of work.
Proportions of concrete.
Shape and finish.
Steel Bridges—
Shop inspection:
Sizes and weights given on plans.
Quality of material as per specifications.
Workmanship.
Shop painting.
Riveting.
Field painting.
Anchorage.
Expansion.
Concrete Bridges—
Proportioning of concrete.
Placing of steel.
Quality of steel.
Alignment of forms.
Finish of forms.
Stiffness of forms.
Expansion.
Wooden Bridges—
Material.
Bearings.
Splices.
Treatment of timbers.
Payments—
Adjustment of Extras—
Settlement of Disputed Points—

PLANS

Plans for bridges or culverts will be furnished on request by the State Highway Department, so far as its appropriation permits, or it will examine and check over plans previously prepared by or under the direction of the counties, and make recommendations in regard to the work. For such of the counties as are not at present so organized as to be prepared to draw up these plans, a competent and disinterested engineer should be employed or the preparation of plans be turned over to the State Highway Department if desired.

GENERAL REQUIREMENTS

Plans should always contain sufficient detail to fix definitely the location, elevation and, as a rule, the design and dimensions of all parts of the structure.

For steel trusses, however, an outline plan will be sufficient, showing stresses provided for, design of main members and thickness of connections, subject to approval of shop drawings when prepared. Location, elevation and foundation plans should also be given.

SIZE

Plans should, if possible, be made twenty-four by thirty-six inches outside dimensions with at least half an inch border all around.

TITLE

The title should be placed in the lower right hand corner and be such as will identify the bridge by name and location, and if more than one sheet is used the identification should be upon them all.

MAP OF SITE

Profile of the river bed and contour map of the ground at the site should be drawn up on a separate sheet in a manner similar to that shown on Plate II.

REFERENCE POINTS

The map of site should show the north point, and reference marks should be given, accurately tied into the bridge itself, so that prospective bidders and subsequent builders may properly understand and construct the work.

FOUNDATION DATA

Lowest water level and depth of foundations below it should be recorded on the plans, together with character of material for foundation work and full information as to number, spacing and length of piles, if they are used; assumed load per foot on foundations; liability to scour, and any means, such as riprap or sheet piling, proposed to be used to prevent it.

QUANTITY ESTIMATES ON PLANS (As Constructed)

In the upper right-hand corner or at other suitable place on the general plan, the weight of structural steel, yards of concrete, weight of reinforcing steel, board feet of lumber and brief quantity summary of any other material entering into the structure covered by the plans, should be entered as separate items after the contract is completed, so that if, at any future time, comparisons of quantities and costs are desired, the necessary information can be quickly obtained.

FOUNDATIONS

EXPLORATION FOR FOUNDATIONS

The question of how much money can be expended to advantage in determining the nature of foundation material depends to a large extent upon the size and importance of the structure proposed; upon the loading, and upon the type. For more important structures the suitability of foundations can be established only by tests. These tests should be made either by open pits; by sounding with iron rod to depth of from ten to twenty feet, if rock is expected within that distance; by wash borings, or by core borings, if knowledge of the nature of sub-foundations in harder materials is desired.

VALUE OF TESTS

The labor, time and money expended in making necessary tests are often used as an argument against them, but the judgment of any experienced engineer with a knowledge of design is worth while considering in this regard.

The following statement of conditions governing the design and cost of foundation work shows clearly why the engineer representing the county should make these tests before plans and specifications are made and bids invited.

(a) If reputable contractors are invited to bid on uncertain knowledge, their proposals will, in the majority of cases, include a provision for such risk greater than the cost of reliable information would be to the party purchasing the structure.

(b) Furthermore, designs when made on insufficient data often call for a larger and more massive foundation than would be planned if conditions were more accurately known. Or, on the other hand, may call for what developments show to be an inadequate foundation and the proper redesign and payments to the contractor for extras will prove more costly than a foundation properly designed originally on more accurate data obtained in advance.

(c) Proper designs on known conditions eliminate to a large degree questions of extras and arguments over conditions affecting unit prices.

BORINGS

For an important bridge crossing two sets of borings should be made.

(a) Borings along the center line, and from them if favorable, the determination of practicable, and, so far as possible, economical location of piers.

(b) After tentative location of piers, additional borings, at least one in each corner, and, if necessary, intermediate ones at the site of each pier.

OBSTACLES

In connection with both of the above sets of borings, data regarding obstacles will be obtained.

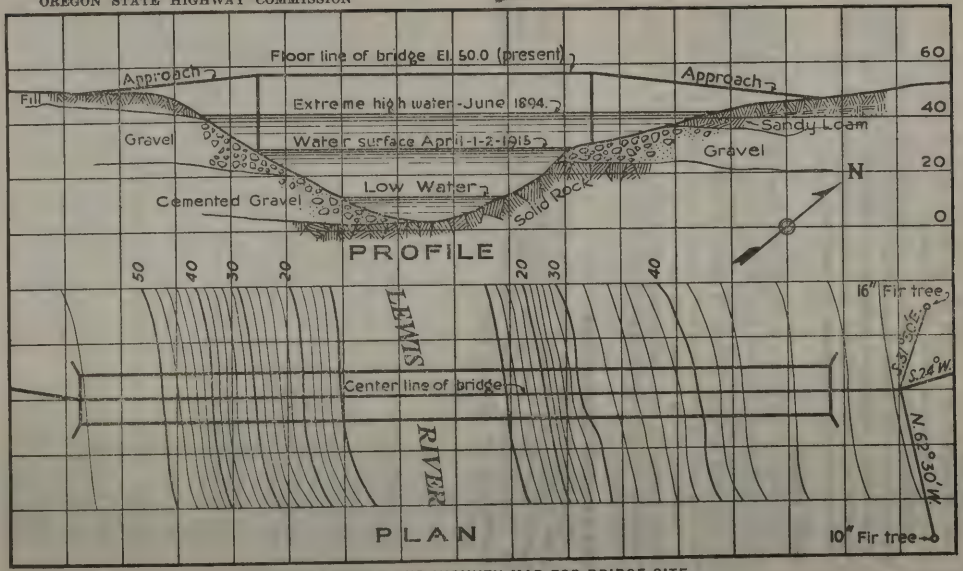
In the exploration of the sites of tentatively located piers, the water jet in connection with wash borings will reveal the location, form and nature of obstacles such as logs, boulders, etc., and will aid in determining whether the pier locations can to advantage be shifted.

TEST PILES

For smaller highway work, in few cases where pile foundations are used, can the contractor drive the test piles with any economy until he is ready to drive the permanent piles for the pier footing. Time is then an important element in securing new piles of suitable length, and money a factor to be reckoned with when the purchaser comes to pay for waste material, as under any equitable contract covering additions to or deductions from lengths of piles, he is bound to do.

ALLOWABLE PRESSURES

Allowable foundation pressures which, in the absence of more definite information, may be used in design of abutments and piers, are given in Specification "B," included in this manual. They indicate the range of values determined by various tests.



TYPICAL PROFILE AND VICINITY MAP FOR BRIDGE SITE

SURVEY OF SITE

(Data Required)

GENERAL INFORMATION

(Please answer every question)

1. Width of roadway desired?.....
2. Type of floor wanted—wood or concrete?.....
3. Type of joists wanted—wood or steel?.....
4. Number of sidewalks required?.....
5. Width of sidewalks?.....
6. Type of bridge preferred—steel, concrete, or wood?.....
7. Give date and elevation of **extreme** high water.....
8. Give date and elevation of **average** low water.....
9. Is the crossing on a "trunk" or secondary road?.....
10. If grade has been established show elevations on profile
11. Distance from bridge-site to nearest railroad station?....
12. Condition of road from railroad station to bridge-site?
13. Can sand and stone for concrete be obtained locally? If so, give distance from bridge-site.....
14. Can timber for falsework and piling be obtained locally? If so, give distance from bridge-site.....
15. Is there a bridge at this site at present? If so, indicate location on map and profile.....
16. Will it be necessary to maintain traffic during construction of new bridge?.....
17. Is design of approaches desired?.....
18. If earth-filled approaches prove economical, is suitable material available for filling?.....
19. Will the approaches be constructed by county forces?.....
20. Give date of desired completion of structure.....
21. Give direction in which roads will approach bridge.....
22. Note if there will be plenty of clearance for swinging teams in narrow canyons or bluff surroundings.....

MAP AND PROFILE OF BRIDGE-SITE

Over .....

(Creek or River)

in Section....., Township....., Range....., W. M.,

near ....., ...

(Town or City) (County)

CERTIFICATION

I hereby certify to the correctness of this map and profile, and the other information contained on this sheet.

(Signed) .....

(Name)

.....

(Official Title)

IMPORTANT FEATURES, GENERAL LAYOUT

FREE WATERWAY

The waterway under freshet conditions must not be so reduced by banked approaches or in other ways as to pass all the water through a narrow channel and thus scour under abutments or piers founded on clay or other loose material, notwithstanding the fact that under ordinary conditions the depth of foundations below the river bed would be sufficient.

If in doubt, use piles.

NUMBER AND LOCATION OF PIERS

If no other conditions were to be considered, the length of spans and the piers carrying them would in general be such that the cost of the superstructure would be approximately equal to the cost of the substructure. But other factors, such as free waterway, foundations, location of main channel, ice and navigation often affect the final decision.

FACTORS IN LOCATION OF SITE

One of the most important matters in connection with bridge economy, considered in conjunction with safety and service, is the determination of the proper location for a site.

The fact that a site permits the shortest span or least cost of combined superstructure and foundation, considering the bridge itself independently of surrounding conditions, is not always sufficient reason for acceptance.

The following factors should all be examined carefully before locating a bridge at any given site:

1. Flow of stream and direction of current, considered from an engineering standpoint in regard to piers and abutments affected by ice, current, scour and silt.

2. Costs of right of way and difficulties of securing same from other standpoints as well, especially in towns and cities.

3. Navigation as regards:
   - Channel span.
   - Clearance for boats.
   - Dock and wharf rights adjacent to bridge.

4. Suitable foundations:
   - Material of stream bed.
   - Ability to handle construction below water line.
   - Obstacles which may be encountered.

5. Clear room for short turns in roadway of approaches, especially in narrow canyons where the road on either side of the stream often follows the canyon walls not far back from the water's edge.

6. Direction of approaches and possible necessity of skew bridge.

7. Necessity of fitting in economically, both roads and bridge being considered, with the required grade elevation of approaching roads and clear heights above high water.

8. High water conditions independently considered.

9. Relation economically with requirements of traffic; that is, for a certain traffic service within the range of influence of the bridge, the cost of the bridge plus the cost of roads leading to it—unless engineering features have to govern—should be an economical minimum, and the extent to which the range of influence above mentioned will be affected by future development of the surrounding region is also a factor of considerable importance.

10. In certain limited cases, as on some state highways and scenic roads, the location with respect to scenic advantages will enter into consideration.

DANGEROUS TURNS IN APPROACHES TO BRIDGES

One objection to Howe truss, **where housed,** as it should be for preservation of bridge itself, is that unless the approach to the bridge from either end for a considerable distance is along the axis of the bridge, there is danger of two teams or autos approaching from different directions meeting each other, as any vehicle on the bridge would be concealed from view of another coming up on an angle or curve.

INSPECTION OF BRIDGES

PERIODICAL INSPECTION AS TO CONDITION

It would hardly seem necessary to call attention to the importance of a periodical inspection by experienced bridge men of all bridges on county roads, yet many counties are neglecting this altogether or investigating conditions only after troubles arise.

Records of inspections and recommendations should be kept on a form prepared for that purpose so that no important feature will be overlooked. Data will then be available concerning all bridges so that a consistent road and bridge plan may be outlined in advance.

MAP INDEX

A common and satisfactory method of keeping track of bridges is to give each bridge a number and on a fairly large scale map of the county, indicate each crossing by a pin to which a corresponding numbered tag is attached. This tag might give span, type (wood, steel or concrete), and condition. The number furnishes ready reference to the record files.

ANNUAL REPORT

An annual report, based on these inspections, should be made by the party in charge of bridge work and special reports at once in case emergency action is needed. This should be a distinctly bridge report of a systematic inspection of bridge conditions.

BEST TIME FOR INSPECTION

In practically every county in Oregon the best time for bridge inspections is in the fall, say from August until November, as during this period weather conditions are best throughout the State and the streams are all so low that foundations can be examined more satisfactorily then than at any other time.

WINTER BEST TIME TO LET CONTRACTS

With plans prepared in the late fall and early winter, contracts can be much more advantageously let in the winter and early spring than after the contractors and sub-contractors have loaded up with work for the construction season. This difference is very real, and has run as high as 15 per cent or more, depending on how early in the winter contracts are placed.

INSPECTION TO DETERMINE STRENGTH OF EXISTING BRIDGES

FOUNDATIONS

Foundations should be inspected chiefly to determine the risk or existence of undermining; the nature of the river bed upon which the substructure rests; direction of current and probable permanence of channel; any new data concerning high water marks; sizes and dimensions of piers, abutments, etc.; evidence that concrete or other masonry is resisting wear.

STEEL BRIDGES

In case the strength of a bridge under inspection be questioned, sketches in complete detail should be made, showing clearly the sizes and dimensions of all members; also details including size and number of rivets in connections, sizes of pins, etc. The condition of bridge as to corrosion of steel and need of paint should be carefully noted. The rigidity of the bridge and stiffness of lateral systems should also be clearly set forth.

CONCRETE BRIDGES

Examination should be made as to settlement in piers, columns or abutments and erosion under them; cracks and spawls resulting from such settlement or from expansion and

CRIPPLED SPAN CAUSED BY UNDERMINED ABUTMENTS

Photo No. 3

Photo No. 1

POST LATTICE BARS TOO FLAT AN ANGLE—SHOP DETAILS AND SHOP INSPECTION FAULTY

contraction; loss of alignment; porosity and resulting staining; hardness of concrete or incipient disintegration; mud cracks, separating different pourings of concrete; integrity of surface finish.

HOWE TRUSSES AND WOOD FRAMED STRUCTURES

Instructions for recording inspection of these structures are given in detail for the reason that not only is this the predominating type in the State, but in few cases can records concerning these bridges be found. In consequence the data have all to be compiled in the field.

Following is the general information required:

A. Draw sketch at the site of bridge, showing on plan and elevation the following information:

Number of panels.
Length of panel.
Span of bridge.
Height of trusses (c. to c. chords).
Size and number of wood diagonals.
Size and number of vertical rods (if upset, note).
Size and number of wood counters.
Size and number of bottom chord members.
Size and number of top chord members.
Arrangement of bottom chord, both trusses, showing splices.
Size of portal members.
Size of sway members.
Size of bottom lateral members.
Size of top lateral members.
Size and number of wood seats at abutments and over piers.
Size of floor joists or size of floor beams.
Size of floor stringers.
Size of floor plank.

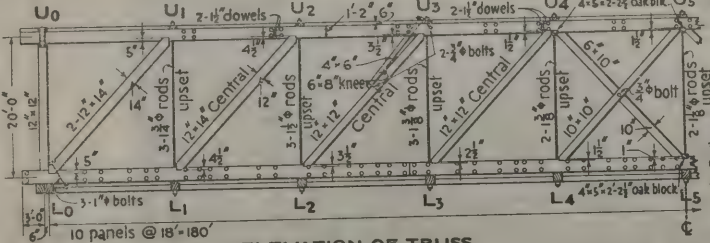
B. If housed, get the following data *re* housing:

Height of siding.
Material of siding.
Size and number of girts.
Size of rafter plate.
Size of collar beams.
Size and spacing of rafters.
Material and spacing of roof sheathing.
Material of roof cover.
Pitch of roof.
Overhang of roof.
Exposure to wind.

C. Make the following general notes *re* material:

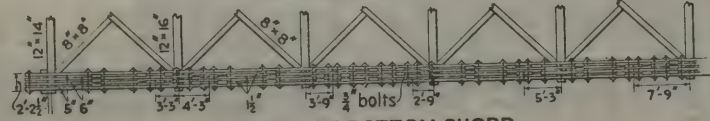
Size of felloe guard.
Size of rails.
Size of packing blocks.

PLAN OF TOP CHORD

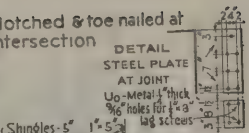


ELEVATION OF TRUSS

HOUSING REMOVED



PLAN OF BOTTOM CHORD



HALF SECTION ON ℄

NOTES

Bolts in chord members ¾" diameter; washers 3" diam. Camber, 9". Care must be taken in framing not to make saw cuts deeper than necessary. Lower chord to be 4-leaf; upper chord to be 2 pcs. 12"×14" Paint ends of members with hot tar before placing. Cut and place counters after bridge is swung. Notch floor beams 2" for laterals. Details on separate sheet.

Plate III

OREGON STATE HIGHWAY COMMISSION

TYPICAL HOWE TRUSS

Number of packing blocks to panel.
Sketch of splices with dimensions.
Diameter, location and number of transverse chord bolts along panel and with respect to packing blocks and splices.
Sketch of angle blocks, showing particularly:
(a) Depth of lug.
(b) Shoulder at bottom of slope.
(c) Thickness of metal.
(d) Diameter of holes.
(e) Length of blocks.
(f) Any information necessary for calculation of weights.
Width and thickness of bearing plates, top and bottom chords, for vertical tension rods.

D. Obtain the following data for use in case falsework is necessary to repairs:
Distance from water line, at probable working stage, to under side of chords.
Depth of water at that stage.
Character of bottom.
Probable velocity of current.
Material for falsework.
Proximity of another crossing.
Kind of piers.

E. Make particular study of the following points during inspection:
Minimum sections of chords in tension.
Opening between chord members.
Saw cuts and minimum sections of splices.
Splices in shear—are they intact?
Splices in bearing—is bearing crushed?
End of chord member at splice:
(a) Is it sheared?
(b) Is bearing crushed?
Is there a double splice on interior members?
Is there a double splice (two wood or one wood and one iron plate) on outside members?
Ends of chord at end post—are they sheared off by angle blocks?
Packing blocks:
(a) Are they well pulled up by transverse bolts?
(b) Are they canted or defective in shear or bearing?
At angle blocks:
Is wood crushed in bearing of lug or sheared off on upward trend of grain in wood?
(b) Are blocks bearing against rods?
(c) Are rods strained in bending?
(d) Is there appearance of heavy crushing across grain of chord?

Note.—Any defects at angle blocks are liable to be noticeable toward end panels and both top and bottom chords should be examined.

Is wood crushed under bearing plates top and bottom chords, where vertical tension rods pass through?

In web members note net sections—reduction due to notching.

Examine web members (in compression) for unsupported lengths so as to be able to use column formulae correctly.

Are counters bearing?

Camber in truss; how much?

Deflection in truss; how much?

If floor system is that of transverse joists, how far across chord do they extend?

How are portal members attached to trusses for stiffening effect?

Top and bottom lateral systems—are they well drawn up?

Lateral systems:

(a) Notching.
(b) Angle block bearing.
(c) Other method of junction.
(d) Provision against dropping out when slack, and if so, what?

F. Obtain, if possible:

Name and address of contractor.
Cost of bridge.
Date of erection.
Strain sheets used.
Loadings estimated.
Plans and specifications used by contractor.

G. After obtaining above field information:

Draw up strain sheet and dimension diagram.

(a) Strain sheet to show stresses under live load (assumed) and dead load (calculated) entered on diagram separately.

By comparison of actual dimensions with stresses obtained as above, deduce the following:

(a) Unit strains in main members and at joints and splices, under actual dead loads.
(b) Unit strains in main members and at joints and splices, under actual dead plus assumed live loads.

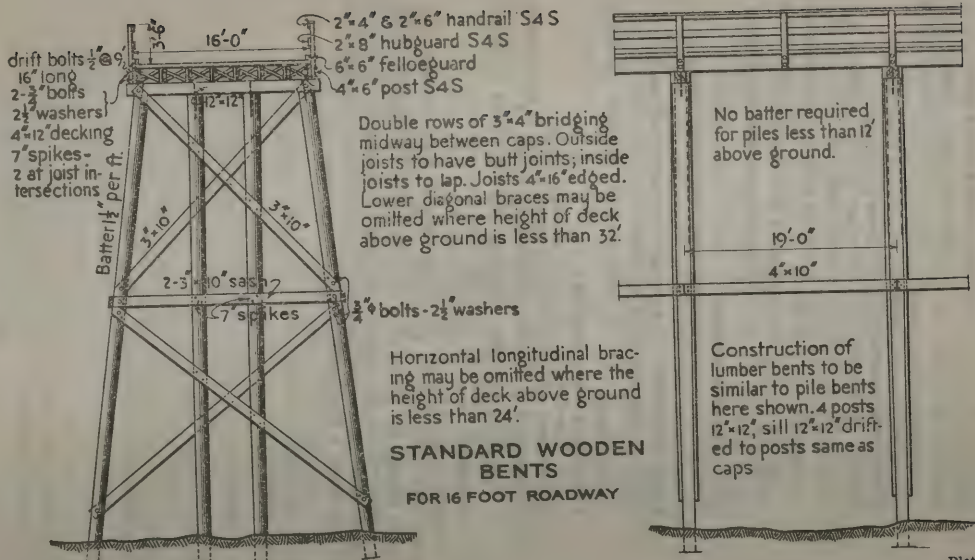
H. Report should discuss:

Condition of material.

Strain in various members under actual dead load and reasonable assumed live load, considering length of span and location of bridge.

Capacity of actual sections to meet these strains.
Recommendations for strengthening main members.
Strength of splices and packing blocks in bearing, shear, tension and compression.
Bearings of angle blocks in shear and compression.
Crushing of bearing plates at vertical rods.
Effects of friction and bearing against vertical rods under heavy tension; also of counters, in considering any tendency of angle blocks to slide under horizontal component of web stress, or shearing and crushing at bearing of lug, where dapped into chord.
Recommendations as to remedying weaknesses at joints and splices.
Deflection and camber.
Strength of floor system and recommendation as to maximum allowable concentrated loading.
Clear statement of assumed uniform live loading on which conclusions are based.
Adequacy of lateral system and whether it needs adjustment.
Portal and sway bracing:
(a) Recommendations.
Adjustment of counters and elimination if not needed.
Elimination of deflection and work involved in it, or in any other changes involving loosening and slackness (during repairs) at the joints.
Estimated cost of changes.

Note.—Appearances are often deceiving in wooden timbers, and where there is reason to doubt their soundness, holes should be bored with a small auger at points where the strength of the timber will not be materially affected. These holes should not be bored in the bottom of joists, but at the sides, a few inches from the bottom.


16'-0"
2"×4" & 2"×6" handrail S4S
2"×8" hubguard S4S
6"×6" felloeguard
4"×6" post S4S
drift bolts ½"@9' 16" long
2-¾" bolts
2½" washers
4"×12" decking
7" spikes - 2 at joist intersections
Batter ½" per ft.
12"×12"
3"×10"
3"×10"
2-3"×10" sash
7" spikes
¾" bolts - 2½" washers
Double rows of 3"×4" bridging midway between caps. Outside joists to have butt joints; inside joists to lap. Joists 4"×16" edged. Lower diagonal braces may be omitted where height of deck above ground is less than 32'.
Horizontal longitudinal bracing may be omitted where the height of deck above ground is less than 24'.
No batter required for piles less than 12' above ground.
19'-0"
4"×10"
Construction of lumber bents to be similar to pile bents here shown. 4 posts 12"×12", sill 12"×12" drifted to posts same as caps

STANDARD WOODEN BENTS

FOR 16 FOOT ROADWAY

INSPECTION OF NEW CONSTRUCTION

DUAL INTENT OF INSPECTION

The twofold value of inspection of work under construction is not always comprehended, but real inspection should include not only the securing of good materials and workmanship from the contractor, according to plans and specifications, but its object should also be to foresee and help avoid false steps in construction progress which would incur not only expense to the contractor, but trouble and misunderstandings to the owner and contractor alike. If possible to avoid it, no work should be allowed to reach a construction stage involving removal of materials, with the labor and loss attendant upon it, if by reasonable care in the course of the day's work, the defects in workmanship or material could have been foreseen and attention called to them. This is a matter of self-interest and business sense.

FOUNDATIONS

Inspection of foundations of bridges under construction should include a thorough investigation of the underlying river bed upon which piers or abutments will be placed or into which piles will be driven. It is upon this observation that the actual depth of footings will be decided, and no such footing should be placed until permission is given by the engineer. The inspector should take, at this time, all notes necessary to establish the elevations adopted for under-surface foundation work, as the chance will not come again. If pile foundations are used, penetration records should be kept so that at all times thereafter the relative position of the river bed will be known.

Observation will help determine whether or not riprap will be necessary as a further protection to foundation work. The contractor's spacing and location of piers and abutments should be carefully checked, as well as the elevations of bridge seats at their tops. General construction features as to workmanship and materials will be found in Specification "B," under "Foundations" and "Concrete in Forms and Steel Reinforcement."

The contractor's attention should be called to the necessity of allowing for sufficient lengths in the sheet piling of his cofferdams, to permit of a small additional penetration and depth of footing if required, and to meet the risk of sudden rises in the stream.

STEEL BRIDGES

Shop Inspection—Shop inspection of the fabricated steel entering into a bridge is, for proportionate value, the cheapest item in the construction cost. The service rendered is just this :

Plans and specifications call for certain materials, dimensions, weights and thicknesses of members and connections, and certain standards of workmanship. The place to check these up is in the shop where the work is being done. The first coat of paint to be applied is the most important, and that also comes under supervision.

The various elements of shop inspection are discussed under the heading of "Shop Work" in Specification "B," which follows.

Defects may be discovered in the shop and remedied there at far less expense and delay than would be entailed if the material reached the field and were there rejected at a time when it was needed at once to maintain the progress schedule of the work.

The cost of such shop inspection by a capable, reliable and disinterested engineer would be, say, twenty dollars for an ordinary 150-foot highway span, and proportionately for other lengths.

Field Inspection of Steel Work—This inspection should cover the general points mentioned under "Erection of Bridges" in Specification "B."

The shipments of material received should be checked over independently of the contractor so that comparison may be made on the basis of shop-inspected material; also in order to assist the contractor to avoid delay through incomplete or faulty shipment.

Members bent out of shape should be straightened.

Inspection of Field Rivets—This work should be done by someone having practical and extended experience in this special line. The method is about as follows: The head of the rivet is struck a sharp blow with a light hammer at an angle of 45 degrees. Ordinarily any looseness will show at once. If in doubt, press a finger against the opposite side of the rivet head struck, and at the junction of the head and the body of the member. If the rivet is loose a distinct jar will be apparent.

Importance of Rivet Inspection—Regarding inspection of rivets in steel bridges, perhaps the best way to bring out the importance of competent inspection is to state that the joints of the bridge are designed with as much, if not with even more care, than the proportioning of the main members, and certainly at a greater expenditure of time. The number of rivets at each joint is carefully calculated. The size, and in consequence, the weight of the connection plates is absolutely dependent upon and drawn up to suit the number of these rivets, finally adopted as necessary to develop the full strength of the main members. When it is realized that in the average riveted-joint highway bridge the connection plates, angles and rivets for the joints form about 35 per cent of the weight of the bridge, exclusive of

joists and fence, the folly is seen of providing all this metal in the connections unless it is necessary to and utilized by rivets that are actually doing work to their calculated amount.

CONCRETE STRUCTURES

Value of Inspection—In no other kind of construction is continuous inspection so necessary as in concrete, and especially reinforced concrete work. A few bad batches of concrete in a vital point may cause the failure of a bridge. Reinforcing rods may be placed so far out of their proper location as to be useless.

Reinforced concrete, properly built, is practically indestructible and constitutes therefore the long-term as well as often the short-term economical material, if suitable conditions for its use can be found.

In this State contracts for concrete structures of certain types and considerable magnitude have been closed at lower figures than those offered for steel. Thorough vigilance from start to finish is the price that must be paid; it is a price that should not be begrudged.

General Requirements—General requirements for concrete work which inspection should cover are stated under the heading of "Concrete in Forms and Steel Reinforcement," in Specification "B," which follows, and need not be elaborated here in detail.

Main Features—Especial attention is directed, however, to the necessity for tight, well-supported, rigidly-braced, properly-spread and easily-removed forms; to true alignment, properly proportioned concrete, acceptable materials and thorough mixing. The forms must be carefully cleaned out and kept clear of shavings, debris, or other material that would interrupt the continuous concrete bond. Proportions of water, method of pouring concrete and spading surfaces must be correct. The steel must be held rigidly in proper position until the concrete is poured and set; it should be so arranged and concrete so worked in around it that the bond adhesion will be maintained.

Fresh concrete must not be jarred by heavy loads being carried over it. Finished surfaces, where specified, must be taken care of in the forms; expansion joints be provided, and all concrete must be properly cured. The required camber should always be maintained. Above all, the forms must not be removed too soon or subjected to heavy loads until permitted by the engineer. Pouring of concrete in freezing weather should be allowed only under direction of a competent engineer, as an emergency, and no frozen materials must ever be used.

Removal of Forms—The time for removal depends largely on the following conditions:

(1) The consistency of concrete, whether wet or dry.
(2) The relative mass of concrete in the member.
(3) The temperature.
(4) The humidity.

Generally speaking, one to three days should be allowed for walls in masswork.

For thin walls in summer, two days; in cool weather, five days.

Slabs in summer, six days; in cool weather, two weeks.

Beams and girders in long span slabs in summer, ten days to two weeks; in cool weather, three weeks to one month.

Column forms in summer four days; in cool weather, six days, providing weight of floor system is kept off of them.

Arches of small size, one week.

Arches of large size, with heavy dead load, one month.

All these periods are bases only for the exercise of experienced judgment.

Materials of Concrete—Cement should be examined for quality along the lines mentioned under the heading of "Tests."

Reinforcing steel should be inspected before shipment if the job is of any size, and be subjected to further physical tests upon arrival at the work.

Sand and gravel can be roughly judged on the ground and sent to the testing laboratory if further information is necessary to proper use. For purposes of rough determination of sizes and grading of the aggregate the inspector should have a set of screens ranging from 1 inch down through ½, ¼ and ⅛ to No. 50. This is a necessity in keeping a concrete mix up to standard where pit-run gravel is used. A glass graduate can be used to determine the percentage of clay or earth in the sand.

Proportioning of Concrete—The requirements as to the relative amounts of cement, sand and gravel are given in Specification "B" of this book. Bank or pit-run gravel should be used for Class A concrete only under exceptional circumstances and with experienced engineering supervision continuously throughout the work.

Object in Proportioning Concrete—The chief object in specifying concrete of certain proportions is not to spend a given amount of money, but to get a certain degree of strength.

Elements of Good Concrete—By securing a well-graded sand and gravel, breaking up their uniformity and thus filling up the voids, then insuring that both are clean and

hard, and that the finest sand is not too fine; by mixing this aggregate thoroughly with the cement and adding a proper amount of water instead of trying to break the record of a day's run, a concrete can be obtained of much greater strength, for a given amount of cement, than that secured with fine, even-grained sand, ungraded gravel, or dirty, soft material in either or both.

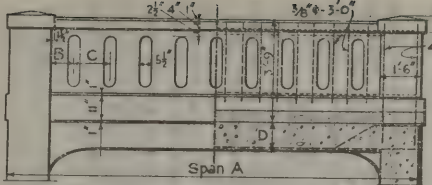
No rule of proportioning the relative amounts of cement, sand and gravel or broken stone is worth much unless these other elemental features of good concrete be observed.

Samples of Concrete—Samples of concrete should be taken from time to time and be cured in little box molds 8x8x8 inches on a side. These samples can be roughly judged by an experienced inspector in a short time after setting with fair accuracy for ordinary work, but for absolute determination of strength they can be broken in special apparatus found in testing laboratories.

Falsework—Falsework for concrete bridges and any other type bringing heavy loads on temporary supports should always contain reasonable provision against crushing of stringers, caps and especially shims and wedges when the load is applied at right angles to the grain of the wood. Suitable and sufficient wedges, working between resistant bearings, should be kept in readiness to bring the structure back to line.

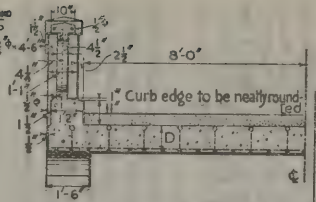
WOODEN STRUCTURES

Bridges of this type require a thorough inspection of the material in the timbers of which the members are made up, and of the measures taken to waterproof the bearing ends. Acceptance or rejection of these timbers should be made, in fairness to the contractors, before they are put in place; provided sufficient notice has been given to the inspector of the program of work, arrival of the material and accessibility for inspection purposes. Splices should be all checked over and bearings examined. Especial attention should be paid to saw cuts in the chords to see that the section is not reduced beyond the calculated amount. Trusses should be true to line and lateral bracing well drawn up so that the whole bridge frame is rigid. Camber should not be overlooked. Packing blocks should be all placed with bolts well pulled up against iron washers, of adequate size to prevent crushing of the wood. Care should be taken not to bring undue initial stress into the splices.



HALF ELEVATION

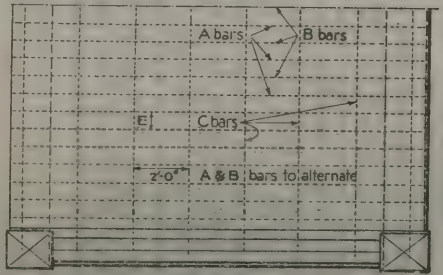
HALF SECTION



HALF CROSS SECTION

BENDING OF "A" BARS

Span	a	b	c	d
10'	1'-6"	1'-3"	4'-6"	7½"
15'	1'-6"	1'-6"	8'-8"	10"
20'	1'-9"	2'-2"	12'-5"	1'-1"
25'	2'-0"	2'-9"	16'-0"	1'-6½"



PLAN

All concrete 1:2:4. All steel may be plain bars.
Railing to be poured in a separate operation.-
Quantities given are for superstructure only.
All exposed surfaces to be rubbed with carborundum to remove form marks.

TABLE OF SIZES & QUANTITIES EXCLUSIVE OF HANDRAIL

A	B	C	D	E	A Bars ⅝" ⊕		B Bars ⅝" ⊕		C Bars 1" ⊕		*Handrail	Concrete	Steel
Feet	Inches	Inches	Inches	Inches	No.	Length	No	Length	No	Length	Lin.Ft.	Cu.Yds.	Lbs.
10	10	16	9	10	11	10'-0"	12	9'-6"	5	18'-0"	+ 20	6.1	515
15	9	15⅝	12	7½	14	13'-0"	15	14'-6"	8	18'-0"	+ 30	11.8	966
20	9	15⅝	15	5	21	20'-3"	22	19'-6"	10	18'-0"	+ 40	19.0	1860
25	10½	16½	18½	4½	23	25'-6"	24	24'-6"	13	18'-0"	+ 50	28.8	2554

*Handrail here means all steel and concrete above top of curb.

STANDARD SLAB BRIDGE

FOR 16 FT. ROADWAY

OREGON STATE HIGHWAY COMMISSION

Plate V

COMBINATION WOOD AND STEEL BRIDGE—AN UNECONOMICAL TYPE FOR OREGON

Photo No. 5

Constructed 1916 **CONCRETE BRIDGE FAILURE—NO INSPECTION** Photo No. 6

DEFECTS IN BRIDGES

Any statement of the advantages of careful study of conditions in the field and of as careful design by experienced technical men in the office, will not carry much weight unless a review of actual constructed work can be made to emphasize some of the shortcomings of the existing system of bridge design, building and maintenance. The following list of defects and failures is taken from records of such troubles in several states. Many of them are right here in Oregon. While no names or locations are given, these examples are all definite and all are matters of public knowledge. They are intended to be typical and to point out some of the details which have to be borne in mind from the time a bridge survey is started until the structure is completed, damaged, worn out or destroyed.

WATERWAY TOO SMALL

The illustration, Photo No. 1. shows a bridge constructed in the wider parts of a rather narrow draw, and the short approach at the end was an addition tacked on after a washout, due to too narrow a waterway, had occurred.

FOUNDATIONS TOO SHALLOW

Perhaps the most common form of defect or failure in bridges is that proceeding from foundations which do not extend deep enough to escape scour. Tubular piers are rarely carried low enough, whether on solid ground or on piles. Many solid concrete piers and abutments reach but a short distance below the surface and are built on ground which is sure some day to be eroded and result in the structure being undermined. See Photo No. 2.

INSUFFICIENT PENETRATION OF PILING

This gives rise to danger from two sources—settlement of foundations and risk to concrete structures on that account; or scour and consequent weakness of abutments or piers, with danger of complete overthrow. This condition arises frequently from encountering gravel, boulders or logs at depths insufficient to give the necessary lateral stability to substructure work. It is much less frequently due to short piles and unwillingness of the contractor to obtain others.

LACK OF PILING

The bridge shown in the illustration, Photo No. 3, failed through scour under one abutment which should have been built on piles or carried well down into the river bed. The concrete abutment broke into three sections, only one section remaining unmoved; the bottom chord at the end which

dropped was twisted out of shape. The cost of repair to this bridge, which was a comparatively new steel span in good condition, will be many times the cost of securing a good foundation in the beginning.

INSUFFICIENT LENGTH OF WING WALLS

The wing walls are often built too short or at too flat an angle with the face of the abutment to prevent the current eating in behind it. This situation is typical of many bridges in this State. The purpose of the wing wall being to protect the approaches from erosion by the current, which during a rise in the stream has to be deflected past the abutment and under the bridge, particular care should be taken in abutment design if the bridge is located at a turn in the stream.

FAILURE TO DRAIN APPROACHES

Streets or roads back of the abutments often conduct water down grade to the bridge, and if this water is not carefully drained off to one side, damage is almost certain to result. A large double intersection truss was let into the river, due to water entering back of the abutments in this way and eventually undermining the foundations.

INSUFFICIENT HEIGHT OF BRIDGE

A little patience in examining records, investigating banks for water marks and gathering local information, with due allowance for inaccuracies of native observation, will all help in establishing the proper height above danger from floods and ice. While ice jams are as a rule hard to estimate, and in some cases the cost of raising a bridge floor sufficiently to be absolutely free from danger from that source would be prohibitive, yet in the main both ice and floods can be provided against. Not long ago in this State a 120-foot span steel bridge was carried out during the spring floods on an ice jam. This bridge had always been considered to have been placed too low.

NO PROVISION FOR EXPANSION

In a steel bridge, built solidly at both ends into the concrete abutments, important members of the steel structure buckled. This was one of the big bridges of the State.

A concrete viaduct, built with the floor beam and girder floor system, carried on posts, was designed with expansion joints as specified, but through neglect of the contractor these were not properly installed. Contraction during a cold spell resulted in spawls over certain parts where free motion was impossible.

INSUFFICIENT ANCHORAGE

The case of a bridge, a 60-foot pony truss, blown off its abutments and deposited upside down alongside the abutments without disturbing them, is an extreme one, as it is probable no anchors would have held it down, but it is true that often a reasonable anchorage will be sufficient to save a span during very severe floods and winds.

LIGHT SECTIONS DUE TO SKIMPED DESIGN

An old bowstring truss girder failed under the load of a steam traction engine and threshing outfit, which plunged through to the river below.

JOISTS UNATTACHED TO FLOOR BEAMS

A 12-ton tractor went through a 16-foot panel of an 80-foot steel truss simply because the joists, being unattached to the floor beams, slid along the flange of the beam enough to let their ends go free of support; the floor system then went down under the load.

RUPTURED FLOOR BEAM STIRRUP

In this instance a 12-ton traction engine, tank wagon and corn sheller broke through two panels of a highway bridge, due to the section of the hanger to which the floor beam was attached being too small for a modern load and giving way under traffic that is today considered no more than moderate.

TOP CHORD DEFORMATION

In the longer bridges, unless the top chord is adequately stayed against lateral movement, it becomes a strut of a length unsupported in a lateral direction, more or less beyond the limit of safety. There are a number of wooden bridges in Oregon of this kind, where the top chord is buckled and crooked. Temporary traffic over them is safe only while the makeshift braces, used in repairs, remain firm.

Wind stresses, unrestrained by sufficient lateral bracing, often produce the same result.

BRIDGE WITHOUT COUNTERS

This is a very common defect in wood trusses, although sometimes omitted through ignorance in steel bridges also. An example of this, pushed to the extreme, is found in a wooden truss bridge recently built in Oregon, where there is no web bracing at all in the central portion of the bridge. The center floor beam, carrying 22 feet of floor, with roadway 16 feet wide, is suspended from the top chord, which at the center has an unsupported span of 20

feet. The truss is here an open polygon. There are no portals, top laterals or sway braces and no provision for stiffness except that obtained from the gabled roof and sides of housing.

LOOSE RIVETS

Eighty loose rivets were found recently in the bottom chord and floor system of an important pony truss steel bridge in one of the Middle Western states. This type of bridge, above all others, depends for its efficiency on rigidity of construction, which is brought about largely through the tightness of the rivets connecting the parts. As high as 40 per cent of the weight of these bridges is in the details—and much of this weight is wasted if the rivets are not doing their appointed work.

RUST AND ACIDS—LACK OF CLEANING AND PAINT

Numerous examples of steel work, corroded and almost entirely eaten away, are found all over the State. The steel has not been kept properly painted, and in the first instance the thickness of webs and plates has more often than not been too little. Any pockets which are easily accessible retain manure, water and other acids and the end posts of bridges, among the most important members in the structure, are on this account often the most deteriorated. One bridge in the Willamette Valley was found with the section of these members reduced by almost half.

In another bridge of the leg post type, the posts were destroyed by rust within twelve years.

LACING BARS TOO FLAT

The illustration, Photo No. 4, shows an example of single lattice in a main compression member, where the angle made by the bar with the axis of the member is much flatter than that permitted by recognized engineering practice for many years.

DEFECTS IN WOODEN TRUSS BRIDGES

One bridge recently erected in Oregon contained all the following faults:

Poor material in splices.

One end post was cracked diagonally across its section almost through the member.

The extension of the bottom chord, beyond the junction of the end post with it, was insufficient to prevent the risk that the horizontal component of end post stress will eventually shear it off.

Joists were all smaller than specified.

Bearings of wood against wood, and steel against wood were already crushed.

DECAY OF WOODWORK

There are many instances in Oregon of all-wood, or combination wood-and-iron truss bridges, whose woodwork is in an advanced stage of decay. Such bridges are practically all unhoused and exposed to the weather, and the condition of their members, especially at the joints, is such that many of them are unsafe. The cost of repairs to these bridges is heavy and unless they are housed at the same time the only economy possible will be in erecting modern structures in steel or concrete. Photo No. 5 illustrates a combination bridge of 120-foot span whose timbers were recently replaced at a cost of one thousand dollars. A Howe truss is a much more economical type of bridge and can be designed to carry much heavier loadings at the same cost as the type shown, for the reason that for the service rendered, by the bridge as a whole, the percentage of steel is too high.

No bridge of this kind should be permitted unless particular care is taken in the design and construction of the joints and quality of material used.

CRUSHED CAP IN WOOD TRESTLE BENT

This failure, which resulted in a thresher going through a wood approach, was due indirectly to lack of inspection of wooden construction. The direct cause was crushing impact across the grain in the cap, brought upon it by the heavy load.

SPLICE FAILURES—WOODEN TRUSSES

In many of the wooden truss bridges throughout Oregon it will be found that the splice blocks and packing blocks have failed in shear along the grain. It is probable that these splices were wedged in and thus given an initial stress. When the falsework was removed it is fair to assume that a large proportion of the load came on them first, thus causing failure, and that such failed splices had never at any time done any useful work.

POOR CONCRETE

A concrete girder bridge, three spans of 45 feet each; two piers, and abutments at either end, was built two years ago at a cost of not less than $5,000.00 by a contractor entirely unfamiliar with the proportioning of concrete and the construction of forms. This bridge is today warped and twisted all out of shape and the concrete in the abutments and piers crumbles away under the fingers. In a few years it will be worthless.

VIADUCT COLUMNS DEFECTIVE

The recent failure of a concrete viaduct in the Willamette Valley was due almost entirely to lack of inspection. One of the columns, sustaining the girder type of bridge above it,

gave way and the opposite column failed, letting down two out of three panels of the bridge. The contributing causes, which inspection would have prevented, were poor mixing of the concrete; failure to clean out the forms; placing concrete in the columns without a suitable tremie; neglect of proper puddling, and possibly a shortage of cement, though this was not very marked. See Photo No. 6.

SHARP TURN IN ROADWAY

This is an instance of a stream crossing a road at an angle. The attempt was made to economize by placing the bridge at right angles to the stream. The effect is as strange as the result is inconvenient, for a double turn is made in a straight right of way, the road for a long distance on either side of the crossing being absolutely straight.

INSUFFICIENT REINFORCEMENT AND POOR CONCRETE IN CULVERT

This culvert gave way because the designer did not call for enough reinforcing steel in the first instance, nor was it properly placed. The concrete was furthermore of a very poor quality, and in consequence the wing walls fell to pieces and the roof caved in.

LIGHT DESIGN AND NARROW WATERWAY COMBINED

A low short-span concrete bridge across a little creek in a narrow canyon in Eastern Oregon was subjected to heavy attack by a freshet due to melting of snow in the hills above. The design was so light and the foundation so poorly anchored that the bridge was left warped and twisted, leaning toward the down-stream side. It crosses the creek at a sharp angle and is now propped against further overturning by 8x8 timbers braced against the adjacent rock wall.

TESTS

The following tabulation in relation to tests of the principal materials used in construction work is presented merely as an indication of some of the various points investigated in the determination of quality and fitness. These points are:

- **Cement**
  - Fineness—specific gravity.
  - Soundness—time of setting.
  - Tensile strength.
- **Sand**
  - Clean.
  - Coarse.
  - Well graded and not too fine.
  - Hard.
- **Gravel and stone**
  - Size.
  - Grading.
  - Hardness.
  - Shape.
  - Cleanliness.
- **Structural steel**
  - Tensile.
  - Compressive.
  - Bending.
  - Elongation.
  - Elastic Limit.
  - Ingredients.
- **Reinforcing steel**
  - Tensile.
  - Bending.
  - Elongation.
  - Process and manufacture.
- **Lumber**
  - Size.
  - Grade.
- **Concrete**
  - Grade and mix for different classes of concrete.
  - Proportions
    - Water.
    - Cement.
    - Sand.
    - Stone.
    - Gravel.
  - Crushing strength.

Properties of the materials which these tests are required to show are discussed more in detail in Specification "B," which follows.

The State Highway Department has a cooperative arrangement with the Department of Experimental Engineering at the Oregon Agricultural College and will be glad, on request, to negotiate for and supervise the application of results of tests as above outlined, to any particular work undertaken by the counties, which it may have in charge.

PREVAILING PRICES

The cost of any material will always remain what it can be bought for and the following details of cost conditions must be accepted only on that basis. Prices and rates are continually fluctuating, due to more causes than it would be practicable to state. Nevertheless, figures given may be assumed to represent roughly, on December 1, 1916, the prevailing costs in Oregon of cement, reinforcing bars and structural steel. Freight rates explain themselves.

STRUCTURAL STEEL

Fabricated material, f. o. b. Portland, per ton	$100 to $110
Rolled beams and joists, f. o. b. Portland, per ton	90 to 100

CEMENT

Standard brands, f. o. b. Portland in 100-bbl. lots, including discounts and return of sacks, per barrel	$1.85

REINFORCING BARS

Plain bars, mild steel billet, f. o. b. Portland, base, per 100 pounds	$3.50

FREIGHT RATES

The rates from Portland to representative points throughout the State are, on December 1, 1916, as follows: Cement in sacks, carload lots, 4 sacks to barrel. Steel, carload lots or less carload.

	Cement, per bbl.		Structural steel, per ton	
	Min. 30,000 lbs.	Min. 50,000 lbs.	Min. 36,000 lbs.	Min. 40,000 lbs.
To Prairie City	$2.05	$1.90	$20.60	.....
	.....	.....	Min. 30,000 lbs.	.....
To Vale	1.41	.....	$11.00	.....
	.....	.....	Min. 36,000 lbs.	.....
To Enterprise	1.22	.....	$10.60	.....
To Baker	1.10	.95	10.00	.....
To La Grande	1.03	.95	9.20	.....
To Pendleton	.87	.....	.....	$6.00
To Heppner	.76	.....	7.20	.....
To Rock Creek	.61	.....	6.40	.....
To Shaniko	.65	.....	6.80	.....
To Condon	.72	.....	7.00	.....
To Bend	1.14	.75	8.00	.....
To Madras	.91	.68	8.00	.....
To Miller	.38	.....	3.60	.....
To The Dalles	.38	Min. 60,000 lbs.	2.00	.....
	.....	.19	.....	.....
	Min. 36,000 lbs.	.....	.....	.....
To Riverside	$1.98	.....	.....	.....
To Crane	2.32	.....	.....	.....
	Min. 30,000 lbs.	Min. 80,000 lbs.	Less carloads	Min. 36,000 lbs.
To McMinnville	$ .34	.....	$2.40	$2.20
To Tillamook	.67	$ .48	5.60	5.20
To Toledo	.95	.....	9.40	8.20
To Albany	.42	.....	3.80	3.20
To Eugene	.53	.....	5.60	4.60

Present rates of structural steel from Pittsburg to Portland are 80 cents per 100 pounds, in carload lots, and to chief Eastern Oregon points and to Spokane about $1.05 per 100 pounds.

PRICE FLUCTUATIONS OF STEEL

The diagram shown on Plate VI represents price fluctuations in steel from year to year at various stages in its progress from furnace to the erected bridge. The curves representing the costs of pig iron, steel bars and structural shapes are drawn up from data taken from "Iron Age," probably the most reliable trade publication on steel products in the United States, and are based on prices in the Pittsburg district.

Cost at the Bridge Site—The line representing fabricated steel at the bridge site is obtained by adding $50.00 to these Eastern prices on structural shapes to provide for:

Steel inspection.
Fabrication.
Shop inspection.
Waste in fabrication.
Draughting.
Shop painting.
Freight to Portland district.
Road haul.
Handling.

While this assumed figure of $50.00 is not a maximum, it is considerably higher than the mean or average cost of the sum of the items it is intended to cover, within the present zone of steel bridge construction in Oregon.

Cost, Erected in Place—The line representing steel erected in place is obtained by adding $20.00 to the cost of the fabricated material at the site, to cover all costs of falsework, handling, erection and painting, and is a little better than a fair average price for steel bridge erection in this State. This line suggests in a graphical way, for the term of years which it covers, a base line about which, in comparative proximity to it, the prices paid for this work should have ranged themselves.

ROAD HAUL

Teaming rates vary considerably according to the topography of the country and condition of the roads. They also are subject to conditions of supply and demand, but a fair average price for teaming throughout the State is 30 cents per ton mile.

LEGEND.-Basic pig iron *(Iron Age)*..... Valley pig iron *(Iron Age)*..... Steel bars *(Iron Age)*____ Structural steel *(Iron Age)*____ Fabricated steel at site___ includes cost of structural steel at mill plus $50. per ton to cover drafting, fabrication, shop paint, inspection, freight, cartage, handling, profit & contingencies. Fabricated steel in place____ includes cost at site plus $20 per ton. The costs from mill to site & for erection & painting are based on the cost of a large number of structures built in Oregon. Actual costs should run under rather than over the figures given. Prices are for tons of 2000 pounds.

Lowest line represents pig iron (Pittsburg district), next two lines steel bars and structural steel (same place), second line from top fabricated steel at site (average Oregon), top line steel in bridges erected (Oregon).
(See accompanying text for limitations of use.)

DIAGRAM OF COSTS—STRUCTURAL STEEL—FROM FURNACE TO BRIDGE IN PLACE

Plate VI

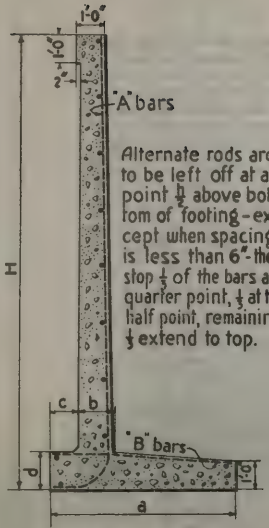

1'-0"
1'-0"
2"
"A" bars
Alternate rods are to be left off at a point ⅓ above bottom of footing - except when spacing is less than 6" then stop ⅓ of the bars at quarter point, ⅓ at the half point, remaining ⅓ extend to top.
H
c
b
"B" bars
d
12"
a

TABLE OF DIMENSIONS & OF QUANTITIES
PER LINEAL FOOT FOR RETAINING WALLS OF VARIOUS HEIGHTS

H FEET	a INCHES	b INCHES	c INCHES	d INCHES	"A" BARS DIAM. SPACING INCHES	"B" BARS DIAM. SPACING INCHES	HORIZONTAL BARS	CONCRETE CU.FT.	STEEL LBS.
8	3'-3"	10	6	12	½"ϕ - 12	½"ϕ - 12	7-½"ϕ	8.3	12
10	4'-0"	10	6	13	½"ϕ - 7	½"ϕ - 8	8-½"ϕ	11.8	17
12	4'-10"	10	8	14	⅝"ϕ - 6	⅝"ϕ - 8	10-½"ϕ	14.6	35
14	5'-8"	12	10	15	⅝"ϕ - 5	⅝"ϕ - 5½	11-½"ϕ	18.5	44
16	6'-6"	14	12	16	¾"ϕ - 5½	¾"ϕ - 6	12-½"ϕ	22.8	63
18	7'-3"	16	13	17	¾"ϕ - 4½	¾"ϕ - 4½	13-½"ϕ	28.4	87
20	8'-0"	18	14	18	¾"ϕ - 3½	¾"ϕ - 3½	15-½"ϕ	35.6	122

NOTE: All concrete 1:2:4 mix; all steel may be plain bars

STANDARD CANTILEVER
RETAINING WALL

OREGON STATE HIGHWAY COMMISSION

Plate VII

ECONOMICAL PROPORTIONING OF AGGREGATE

The excessive costs of freights and teaming in inaccessible districts make it often profitable to study the economical proportioning of aggregate to suit local supplies of sand and gravel. The cost of importing extra cement necessary to make the limited local supply of aggregate materials available, by use of a richer mix possible under the specifications, may be less than that involved in bringing in the extra sand, gravel or stone from the outside.

FLOORS

MAINTENANCE AND RENEWAL

Estimates based on reliable information show that approximately one-half the total of ordinary road and bridge funds is expended on the renewal and maintenance of bridges. In Oregon, floors of county highway bridges are, with few exceptions, laid in wood and the problem of repair and upkeep is serious. This question merits study from the standpoint of capitalization of the annual maintenance cost as compared with the additional expenditure required in the first instance, to construct a reasonably permanent floor.

EXCESSIVE COST OF SMALL REPAIRS

In the case of plank floors, it is no exaggeration to say that the renewal of single bridge planks has cost in many cases as high as $5.00 per plank when the time of supervisor and helper, consumed in going to the mill, bringing plank to the bridge and placing it, is all added to the cost of the material.

LAMINATED WOOD FLOOR

A substitute of considerable merit for the ordinary plank floor is one laid up of 3x8 timbers on edge and covered with a waterproof wearing surface. This floor is light and rigid, and should last a long time. (See Specification "A.")

CONCRETE FLOOR

A concrete floor is the most satisfactory and economical for permanent bridges of heavy traffic design. In such bridges the weight of floor is not so great a proportion of the total load for which the bridge is designed as it is for a medium traffic highway span.

Comparison of Wood and Concrete—In making comparative estimates of the economical features of wood and concrete floors, the additional weight of trusses necessary to carry the heavier floor will be a partial offset to economy of maintenance, and must enter into the calculations. The importance of weights of construction materials increases with the length of span.

Ordinary plank floors on uncovered bridges have an average life of only three to four years.

Elements Affecting Saving—An increase in the cost of structural steel increases the saving in the total cost of bridge for the lighter floors, but an increase in the cost of lighter floor materials decreases such saving.

Rigidity—Concrete floors make a more rigid bridge in every way, and the effect of impact on the floor system is greatly decreased.

Waterproofing—The floor should be waterproofed for wood block finish or surfaced with a wearing coat, preferably of impervious or bituminous material.

The bituminous wearing surface will require a treatment of oil and stone chips or screened gravel at intervals of about four years.

LOADINGS

The question of loads for which modern highway bridges should be designed is one on which there is rapidly coming to be a more uniform agreement between engineers and those who use the highways and pay for them. The tendency has been upward and it is by no means certain that the increase has ceased.

MAXIMUM NOT REACHED

On the contrary, it is practically certain that the maximum loads now traveling the roads and crossing the bridges of this State are not the maximum that they will bear during their estimated life. Any design should be based on this assumption.

RANGE OF INFLUENCE OF UNIFORM AND CONCENTRATED LOADS

In Specification "A" are given the uniform dead and live loads used in common practice for design of bridges. It is these loads which in all but very short spans determine the maximum stresses in a truss or main girder. The concentrated load is the one used in the design of the floor system as a rule, and its range of influence seldom extends to other parts.

PRESENT MAXIMUM

The greatest concentrated loads to which highway bridges are subjected at the present time are road rollers, threshing engines, traction engines and motor trucks, varying from 5 to 15 and sometimes as high as 20 tons.

LOADS ADOPTED FOR DESIGN

The medium traffic bridges of the Highway Department are designed for a 15-ton roller and the heavy traffic bridges

for 20 tons. There is good logic in designing concrete bridges for the greater loadings for the reason that their life is indefinite. The possibilities of what they may have to carry are many. It would entail considerable expense and total loss of the structure and materials in it to blow it up in order to make way for a stronger bridge. See Photo No. 7 for one form of a moderate concentrated load, as such loads go today.

LIFE AND ULTIMATE COST OF BRIDGES

LIFE

STEEL BRIDGES

The life of a steel bridge, based on the assumption that it is worn out and not merely wrecked or displaced by one of greater carrying capacity before it reaches that state, will vary from twenty-five to forty years, depending to some extent on the painting and freedom from salt air, and on absence of gases and corroding acids. Painting should be done every three or four years.

COMBINATION WOOD AND IRON

The ordinary life of an unprotected combination bridge is from twelve to fifteen years, depending also on how well both wood and iron have been painted and maintained.

TIMBER BRIDGES IN THE OPEN

Such bridges last from ten to fifteen years, sometimes less, and as elsewhere stated, floors are only good for from three to four years.

HOWE TRUSS SPANS (Housed)

These spans, when properly covered, will last from thirty to upward of forty years. There are numbers of them in Oregon today, although many were never built for and should not be called upon to carry the loadings specified herein.

REINFORCED CONCRETE AND MASONRY BRIDGES

While these two classes of bridges are grouped together, the reinforced concrete bridge, properly designed and inspected, will have a better chance in this country for an indefinite life than even the high-class masonry structure, built under prevailing conditions.

The long life of either type, however, will make it worthy of consideration in any estimate of ultimate economy based on comparison of cumulative costs of the classes of bridges here discussed.

ULTIMATE COST

BRIDGE ECONOMY

The ultimate cost of a bridge may be taken to be the sum of its first cost plus all charges for maintenance and repairs over the term of its life. The true basis for comparison of costs of any set of bridges is the amount necessary to capitalize in order that the interest may provide for:

1. Maintenance and repairs.
2. Interest on first cost.
3. A sinking fund for depreciation.

The above statement does not include any allowance for comparative service, as they are all assumed to be equal in that respect.

Photo No. 7

AUTO TRUCK LOADED, WEIGHING 14 TONS. IT IS LOADS LIKE THIS THAT YOUR BRIDGE MUST STAND

STEEL SPAN 160 FEET LONG—WOOD TRESTLE APPROACHES

Photo No. 8

STANDARD PLANS

The standard plans found throughout this manual are typical of those on file in the State Highway Department and are all drawn up on the specifications there in use.

Structures both lighter and heavier than those shown can be built. Details either more pared down or elaborate may be found in various bridges throughout the State.

These plans, however, represent good practice for Oregon conditions, and bridges built in accordance with their main features will be economical and safe for any traffic which is likely to develop within their life.

They are self-contained; that is, for each type shown all necessary explanations as to materials, dimensions and general details are given on the same sheets.

CAUTION AS TO USE

While standard plans and specifications are extremely useful, inasmuch as they render possible quick action in getting together the necessary information on which contracts can be let, their adaptation or application to any particular construction should be made only by those having full knowledge of conditions and experience in the work.

See list of "Standard Plans and Diagrams" in front of book.

ESTIMATING CURVES

GENERAL

The estimating curves shown on Plates X, XI and XII are presented for handy reference in determining within reasonable limits the approximate quantities or weights of the materials which enter into the construction of the types of bridges for which the curves were prepared.

BASIS OF CURVES

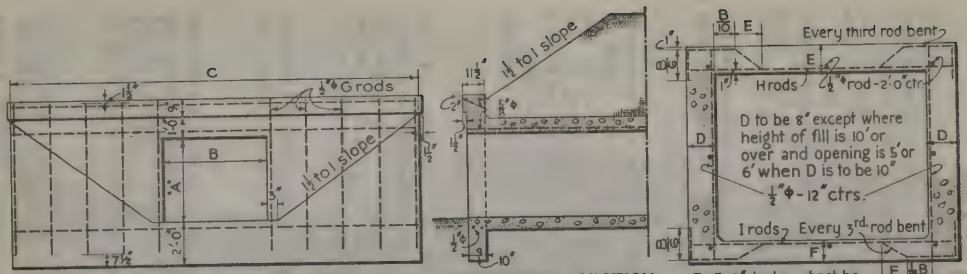
The diagrams are based on Howe truss, pony and through Pratt bridges, designed according to the standards of the State Highway Department for the loadings given.

LIMITATIONS

They are in no way intended as a substitute for careful estimating when the question of any crossing enters the contract and construction stage. The final estimates should always be made up at headquarters on accurate plans and details, worked out for the particular bridge in question to cover any special conditions.

APPLICATION OF CURVES

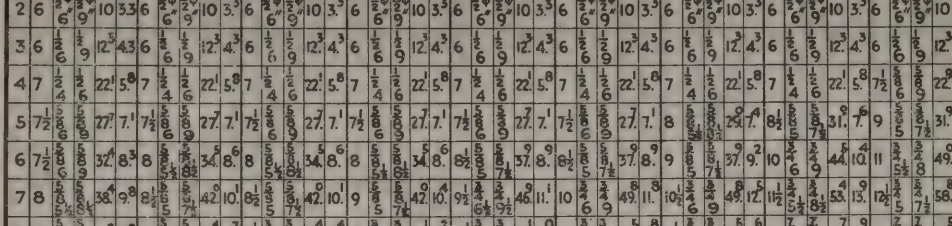
Men in the field, however, are often called upon to prepare an estimate on short notice upon which definite construction programs may be authorized without further delay.


C
G rods
B
A
1½ to 1 slope
END ELEVATION
1½ to 1 slope
LONGITUDINAL SECTION
B
E
Every third rod bent
H rods
½"ϕ rod - 2'-0" ctrs.
D to be 8" except where height of fill is 10' or over and opening is 5' or 6' when D is to be 10"
½"ϕ - 12" ctrs.
I rods Every 3rd. rod bent
F = E - 3", but must not be less than 6"
CROSS SECTION

STANDARD REINFORCED CONCRETE BOX CULVERT

DIMENSIONS & QUANTITIES FOR ONE HEADWALL

HEIGHT-FT	WIDTH OF OPENING, B, IN FEET																																	
	2				3				4				5				6				7				8				9				10			
A	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.	C ′ ″	G Rods	Concrete cu. ft.	Steel lbs.
2	11 6	6	52 8	63	12 6	6	56 1	66	13 6	6	59 5	70	14 6	6	62 5	74	15 6	6	65 7	78	16 6	6	69 1	82	17 6	6	72 3	85	18 6	6	75 5	89	19 6	6	78 7	93
3	14 6	8	78 3	86	15 6	8	81 5	90	16 6	8	84 9	94	17 6	8	87 9	97	18 6	8	90 11	101	19 6	8	94 1	105	20 6	8	97 1	109	21 6	8	100 6	113	22 6	8	103 8	116
4	17 6	10	108 4	112	18 6	10	111 2	116	19 6	10	114 4	120	20 6	10	117 6	123	21 6	10	120 8	127	22 6	10	124 2	131	23 6	10	127 4	135	24 6	10	130 6	139	25 6	10	133 9	142
5	20 6	12	143 1	141	21 6	12	146 5	144	22 6	12	149 8	148	23 6	12	152 7	152	24 6	12	155 9	156	25 6	12	159 2	160	26 6	12	162 5	163	27 6	12	165 6	167	28 6	12	168 1	171
6	23 6	14	183 3	172	24 6	14	186 5	176	25 6	14	189 7	180	26 6	14	192 8	183	27 6	14	196 1	187	28 6	14	199 5	191	29 6	14	202 8	195	30 6	14	205 1	199	31 6	14	208 1	202



NOTE.- Quantities given are for one lineal foot of top and bottom. For various heights of opening add 1.5* of steel and 1.33 cu. ft. of concrete for each foot except where height of fill is 10' or more on walls 5' and 6' in height add 1.67 cu. ft of concrete, and 1.5* of steel

Example.- Quantities in a culvert 5' × 5' × 30' long, 6' fill. Steel = 30 × 26.7 + 30 × 5 = 1.5 = 1026*. Concrete, 30 × 7.1 + 30 × 1.33 × 5' = 413 cu. ft. Two headwalls for culvert (see table on preceding page) - steel, - 2 × 152 = 304.* Concrete, 2 × 152.7 = 305 .

BOX CULVERTS—DIMENSIONS AND QUANTITIES FOR PORTION BETWEEN HEADWALLS

OREGON STATE HIGHWAY COMMISSION

Plate IX

The importance of a fair degree of accuracy is thus easy to understand.

After the quantities of materials are obtained, prices and labor costs can be judged in the field on the basis of local conditions, perhaps better than anywhere else, and the rough estimate be made up in a short time.

HOWE TRUSSES

The curves for Howe trusses were plotted from material lists of spans taken at regular 18-foot intervals, starting with a 72-foot span and ending at 180 feet. (See Plate No. XII.)

The roadway is taken at 16 feet and live load at 75 pounds per square foot, including impact.

Under metal are included all rods, bolts, washers, spikes, nails, etc.

All spans above 72 feet are estimated to be covered, and two curves for lumber are given, one for the trusses and laterals only, and the other for materials in floors, siding and roof, except shingles.

For shingles a separate curve is shown.

STEEL BRIDGES

On Plates X and XI are shown curves giving the weight of steel in both medium and heavy traffic bridges of spans ranging from 60 to 260 feet.

The bridges are of the pony or low truss type, from 60 to 90 feet, and through Pratt trusses from 100 to 260 feet. Roadways are taken at 16 feet.

Live loads for medium traffic were assumed at 60 pounds for spans up to 150 feet, and 50 pounds for spans over that length. Resultant live load stresses in the trusses were increased for impact.

For heavy traffic the live loads were assumed at 100 pounds for spans up to 150 feet, and 75 pounds for greater lengths, the loads given including provision for impact.

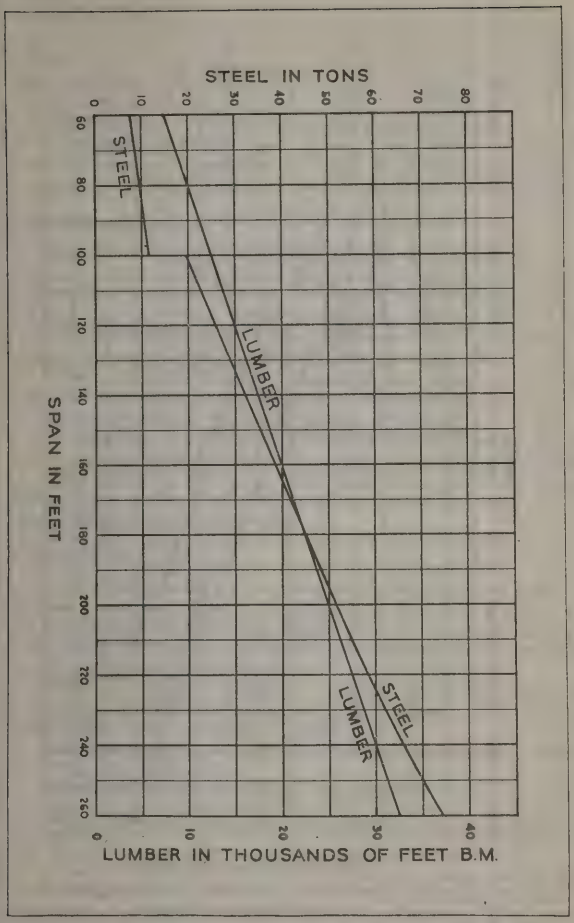
Medium traffic bridges are designed for wood floors and joists; heavy traffic bridges to eventually carry a concrete floor.

CULVERTS

RECTANGULAR AND WIDE-OPENING CULVERTS

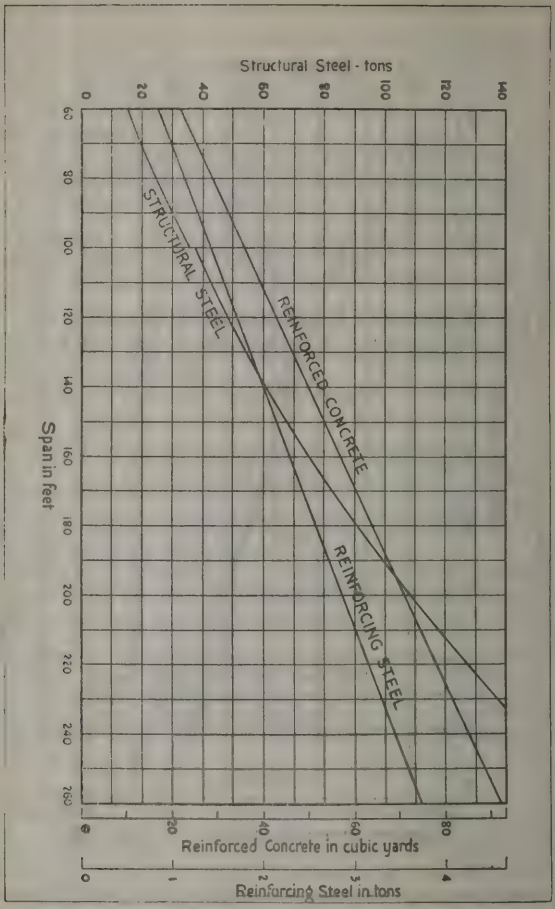
On Plates VIII and IX are shown standard plans of concrete box culverts, in sizes ranging from 2 to 6 feet high and from 2 to 10 feet wide. Quantities of concrete and steel entering into the construction are also given in tables covering the various dimensions.

Superstructures for slab bridges of spans from 10 to 25 feet are given on Plate V and may be applied to culvert work of the larger types.



QUANTITY ESTIMATES—STEEL BRIDGES—MEDIUM TRAFFIC

Plate X



QUANTITY ESTIMATES—STEEL BRIDGES—HEAVY TRAFFIC

Plate XI

PIPE CULVERTS

The most suitable material and requisite sizes of pipe to place at a given point will not be discussed in detail here. Wood, metal, vitrified tile, concrete (both plain and reinforced), are types familiar to most of those who have to do with road work. Costs of hauling and labor to install are equally factors with cost at the shipping point.

Strength, durability and inherent protection against improper placing, furnished by type, all enter into a determination of final economy, as does the cost of maintenance.

CONSTRUCTION

Whatever type is adopted, protection of the roadway requires that the water be prevented from finding its way along the outside of the structure and undermining it. Tight head or wing walls should be provided to properly divert the water through the opening on the upstream side, and to prevent wash where it comes out below.

Foundations should be ample in all cases to suit the allowable pressures on soils given in Specifications "A."

Culverts should be self-cleaning, if possible, or admit of easy cleaning, if not. They should be long enough to include the normal width of section between parapets or headwalls.

For sluggish flow, no pipe less than 16 or 18 inches should be used and sufficient slope should be given so they will drain during low water.

DRAINAGE

General—A small culvert should ordinarily have the same slope as the stream bed; if it have a greater slope, the downstream end will clog, and if a lesser the upstream end will plug. A fall of 1 in 50 is the minimum grade at which a 12-inch pipe should be used.

Where a culvert occurs at the foot of a steep hill, the velocity of the stream is greatly reduced and openings should be correspondingly larger.

Culverts under side roads must be sufficiently long to provide an easy turn.

Drainage Areas as Basis for Culvert Sizes—Wherever possible, the required sizes for any given culvert should be determined by observing the sizes of openings and conditions of flow at other culverts on the same stream.

Where such data are not obtainable, information may be obtained from reliable handbooks, which for different drainage areas give tables in detail of various sizes suited to varying climatological and topographical conditions.*

*The Highway Engineer's Handbook, by Harger and Bonney, is one of the best and most complete in compact form.

The following tables for small culverts were prepared by the New York Central & Hudson River Railroad Company for two conditions of topography, and for drainage areas ranging from 5 to 560 acres. They are suitable as a base upon which the proper sizes for local conditions may be approximated.

The data given are not far wrong in their adaptation to Oregon climatology for the reason that Eastern Oregon is subject to the same sudden rain storms as the territory for which the data were prepared. In Western Oregon, where the total rainfall is greater than that in either the eastern part of the State or in the district tributary to the railroad whose tables are used, the downpour is not so violent and floods are due more to the cumulative effect of many gentler rains. In consequence culverts are subject to a more uniform and steady flow.

DRAINAGE TABLES AND SIZES OF PIPE

Steep, rocky ground, Acres	Flat cultivation. Long valley. Acres	Size Diameter in inches	Equivalent capacity pipes
5	10	10	.....
10	20	12	.....
20	40	16	.....
25	50	18	two 16-in. pipes
30	60	20	two 16-in. pipes
45	90	24	two 18-in. pipes
70	140	30	two 24-in. pipes
110	220	36	two 30-in. pipes
150	300	42	two 36-in. pipes
180	360	48	two 36-in. pipes
280	560	60	two 36-in. pipes

PAINTING

NECESSITY FOR PAINTING

Assurance of painting for steel bridge work, at intervals of not to exceed three or four years, is absolutely essential to the validity of any arguments in favor of steel and against other materials represented to be more costly, less permanent or less strong. The first cost of a steel bridge presents a comparatively large investment for a supposedly superior material, which retains its superiority only so long as its cross-sectional area is maintained intact against corrosion by proper painting. Requirements for painting are stated in Specification "B."

QUANTITY OF PAINT

The amount of paint required per unit of weight or surface area depends to a large extent upon the type of bridge, whether girder, heavy truss or light truss work; upon the shape of the sections which go to make up the members, and upon the cross-sectional area of steel in relation to the surface area bounding it.

For average highway work, however, the following amounts of lead and oil paint mixed in the proportions elsewhere specified, will be required:

One-half gallon first coat, per ton of steel.

Three-eighths of a gallon second and third coats each, per ton of steel.

The average highway bridge members will run about 250 square feet of surface area per ton of structural steel.

LABOR

An experienced bridge painter will average perhaps 400 square feet with lead and oil paint, and, say, 600 square feet with graphite paint per eight-hour day.

HOWE TRUSS BRIDGES

GENERAL

No discussion of bridge work for Oregon county roads would be complete without a fair presentation of the merits of Howe truss bridges properly covered in. It is because they are now and will continue to be an important element in the development of economical stream crossings on secondary roads for some time to come, that they demand and should receive consideration.

LUMBER

Good lumber for bridge timbers is still to be had at points west of the Cascades and at many places in or adjacent to the Blue Mountains of Eastern Oregon, for from $13 to $16 per thousand.

COMPARISON OF WEIGHTS, FREIGHTS AND TEAMING

Span for span, the weights of material entering into freight and teaming costs are about the same as for steel. These bridges, housed in Western Oregon, where the rainfall is abundant, and open in the dry climate of the eastern part of the State, will give long service. While they are hardly as rigid as riveted steel trusses, they are nevertheless sufficiently stiff for highway traffic and are in use for interurban transportation on some of the most prominent electric systems in the Pacific Northwest.

PIERS AND ABUTMENTS IN CONCRETE

Piers and abutments can be put in of concrete adapted to receive steel bridges when the traffic becomes so great as to require a first class bridge or when the old bridges are worn out, as by that time lumber will be worth considerably more than it is today.

RELATIVE COSTS

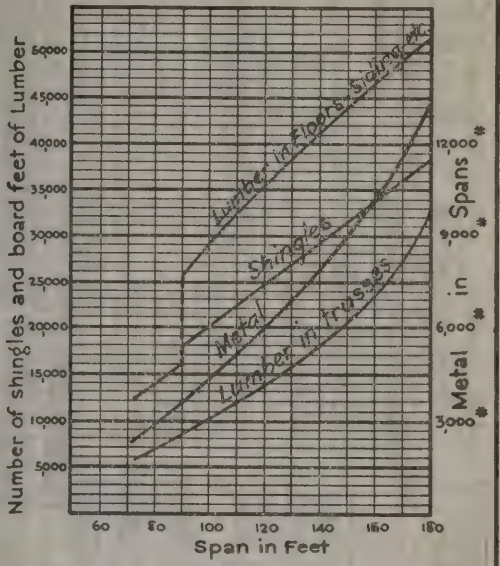
Assuming that the policy is adopted of putting in first class concrete piers and abutments, the first cost of housed Howe truss bridges is as much and sometimes more than 25% less than that of steel. Its life, properly built and subject to the service for which it was designed, will be as long, chiefly, however, to be fair to the steel, because the latter often has not been kept properly painted, no one having taken the trouble to figure up the money loss per year in deterioration.

DISADVANTAGES

Against the advantages which have been mentioned should be considered the greater fire risks, difficulty sometimes in getting teams to cross the dark covered bridges at night and the danger of accidents to teams, or especially automobiles, if the approaches are not on a straight line with the bridge for some distance either way. The appearance can be improved considerably over that of some bridges now in existence, at very little additional cost.

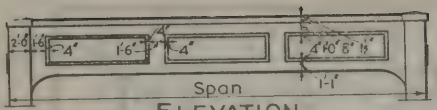
EACH CASE ON ITS MERITS

The question of using Howe truss bridges or any other type for a given locality under given conditions must be considered separately for each case and rest on its individual merits. Not the least will be the financial status of the counties contemplating the work.

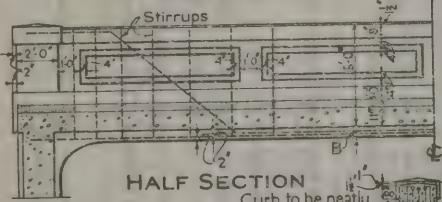


MATERIAL IN HOWE TRUSS BRIDGES

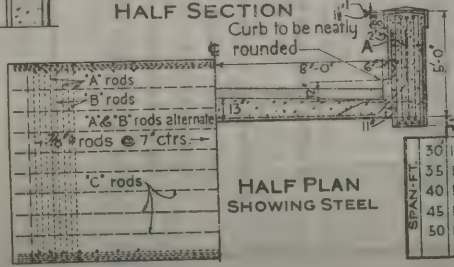
Roadway width 16'-0" Live load 75# per square foot including impact. Span lengths in increments of 18'-0". Metal includes all rods, spikes, nails, etc. All spans above 72' are covered.



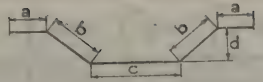
ELEVATION



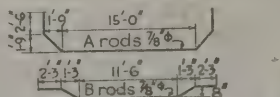
HALF SECTION



HALF PLAN SHOWING STEEL



BENDING DIAGRAM-BEAM STEEL



1'-1" for 30' length
1'-1" " 35' "
1'-3" " 40' & 45' "
1'-5" " 50' length

STIRRUPS

4'-8" for 30' & 35' spans
5'-2" " 40' "
5'-6" " 45' "
6'-0" " 50' "

NOTES

All concrete to be 1:2:4 mix. All steel may be plain rods. Provide returns for curb at ends. All visible surfaces to be rubbed with carborundum stone, to remove form marks.

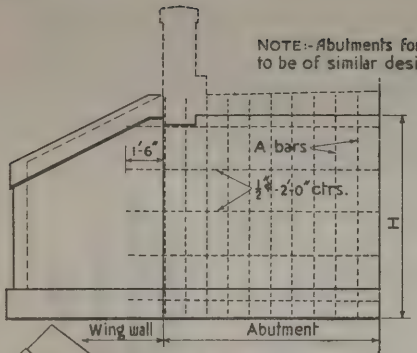
TABLE OF STIRRUP SPACING

SPAN FT	SPACING - INCHES
30	18-21-24-24
35	15-18-21-24-24
40	12-15-18-21-24-24
45	9-10-12-15-18-21-24-24
50	6-7-8-9-10-12-15-18-21-24-24

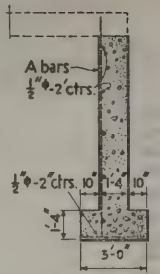
REINFORCING STEEL.

SPAN-FT.	BEAM STEEL-1 SPAM A'	B'	Straight	Bent	a	b	c	d	S-1 A'	S-1 B'	S-1 C'	TOTAL S-1 Lbs.	TOTAL S-2 Lbs.
30	1'-4"	0"	5-1"ø-29'-0"	3-⅞"ø	3'-0"	6'-3"	14"	4'-6"	22	22	8-½"ø-29'	35.2	3450
35	1'-4"	0"	6-1"ø-34'-0"	4-1"ø	3'-6"	6'-3"	18"	4'-6"	26	26	8-½"ø-34'	41.9	4620
40	1'-6"	6"	6-1⅛"ø-39'-0"	4-1"ø	4'-0"	7'-0"	21"	5'-0"	30	30	8-½"ø-39'	51.4	6330
45	1'-6"	10"	6-1⅛"ø-44'-0"	4-1"ø	4'-6"	7'-9"	24"	5'-4"	35	34	16-½"ø-23'	59.5	7310
50	1'-8"	1'-6"	6-1½"ø-49'-0"	4-1"ø	5'-0"	8'-6"	27"	5'-10"	39	39	16-½"ø-25'	74.0	8910

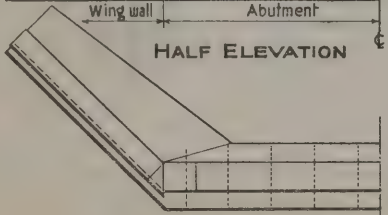
NOTE:- Abutments for slab bridges to be of similar design.



HALF ELEVATION



SECTION THRU ABUTMENT



HALF PLAN

QUANTITIES IN ABUTMENTS

EXCLUSIVE OF WING WALLS

HEIGHT "H" FEET	A BARS DIAM.	A BARS SPACING-IN.	STEEL LBS. PER LIN. FT.	CONCRETE CU. FT. PER LIN. FT. OF ABUTMENT
8	½"ϕ	18	8	13
10	½"ϕ	18	10	16
12	½"ϕ	16	12	18
14	½"ϕ	11	17	21
16	½"ϕ+	7½	21	24
18	¾"ϕ+	11	31	26
20	¾"ϕ+	8	44	29

+Alternate rods to stop half way up.

All concrete 1:2:4; all steel may be plain bars.

The design of wing walls may be obtained by referring to drawing of cantilever retaining walls.—

ABUTMENTS FOR GIRDER BRIDGES

OF REINFORCED CONCRETE

OREGON STATE HIGHWAY COMMISSION

Plate XIV

STANDARD SPECIFICATIONS "A"

FOR

LOADINGS, STRESSES CALCULATIONS AND DESIGN

OF

BRIDGES

OREGON
STATE HIGHWAY
COMMISSION
1916

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GENERAL NOTES

All plans upon which a proposal is made, should become a part of the contract and be sufficiently definite to enable a contractor to use them in constructing the bridge. They should include the following information concerning the structure :

Dimensions of all parts; sectional areas; amount, kind, location and quantity of all materials; type of construction, waterway; and depth of foundations.

Any plan which is so general that it does not cover the above features should receive no consideration in award of a contract and all proposals should be made upon one set of plans and specifications adopted in advance by the county officials concerned.

For the purpose of aiding in drawing up plans which will conform to reasonable requirements of design for modern highway bridges, the following specifications are presented. They do not attempt to do more than outline the practice of the better class of engineers and direct attention to points upon which an understanding should be had. Suburban and interurban county bridges carrying electric cars are not here considered, any such bridges being handled by special specifications. These specifications are confined to highway traffic.

FOUNDATIONS, PIERS AND ABUTMENTS

DESIGN

The design of piers and abutments may be of gravity section, or of reinforced cantilever or counterforted type. Abutments shall be self supporting, with approach fills in place and both abutments and piers shall be capable of resisting the impact of ice jams and floating debris.

REINFORCED ABUTMENTS

When wing walls are located at an angle of 45 degrees or more with the face of the abutment and the abutment is otherwise properly designed, they may be tied together by reinforcing steel to produce cooperative stability with the main wall.

Such abutments shall be calculated to withstand a pressure imposed on the vertical projection of all walls equal to that caused by a fluid of the same depth as the earth fill and weighing not less than 15 pounds per cubic foot.

Similarly where wing walls make an angle less than 45 degrees with the face of the abutment, the fluid shall be taken to weigh not less than 20 pounds per cubic foot.

For reinforced concrete slab bridges, the slab may be assumed to support the top of the main wall against the overturning tendency of the fill.

RESULTANT PRESSURES

Footings of abutments, wings, retaining walls and piers shall be so proportioned that the resultant of all possible forces and combination of forces acting upon them shall fall within the middle third of the footing base.

ALLOWABLE PRESSURES

	Tons per sq. ft.
Alluvial soil	½ to 1
Earth and soft clay	1 to 2
Clay or sandy clay	2
Sand or gravel (confined)	2
Cemented gravel	5
Rock cleaned to solid bed	25

PERMISSIBLE STRESSES

	Pounds per sq. in.
Steel in tension	16,000
Concrete in direct compression	500
Concrete in flexural compression	650
Bearing on bridge seats	400
Bond stress	80

PILING

No pile shall be calculated to carry more than 20 tons under requirements for penetration, fulfilled by application of the Engineering News formula given in Specification "B."

Except for tubular piers, pile spacing shall not be less than 2 feet 6 inches center to center and preferably not less than 3 feet.

The piling, when used, shall be calculated to carry all the load.

Wood piling shall be cut off at low water level and be imbedded from 12 to 18 inches in the concrete base of abutments and piers.

Concrete piles shall be of Class A mix, properly reinforced and may be either precast or poured in place. These shall join the main base at a point below the probability of scour.

DRAINAGE

Adequate drainage shall be provided for the backs and wings of abutments by tile or other pipe drains, running through the walls at the lowest elevation which will insure free outlet.

ICE BREAKS

Piers built in streams carrying heavy ice shall have a satisfactory ice breaker with not less than a 6x6x½ angle or a tee rail embedded in and securely anchored to the pier.

ANCHOR RODS

Where rock foundations are obtained, anchor rods two inches in diameter and six feet long shall be set and grouted into the rock bottom at least three feet and in sufficient number to insure piers or abutments against lateral movement.

BATTER

Batter on the face of all concrete piers and abutments shall be provided where type of construction so demands.

DEPTH OF FOUNDATIONS

In no case, rock foundations alone excepted, shall footings be carried to a less depth below the stream bed than four feet for abutments and piers, preferably six feet for piers and in all cases they shall be carried to a firm foundation, on a material that will remain confined; otherwise piling shall be used.

STEEL TUBULAR PIERS

The State Highway Department does not in general recommend the adoption of this type of piers but in exceptional cases if real economy and adequate security can be obtained through their use, the following specification shall govern in the design:

DESIGN

Tubular piers and their bracing shall be so proportioned as to take the resultant of all loads or combinations of loads such as live and dead loads from the bridge; wind stresses from all sources; stresses produced by current and ice.

Where they will be subject to impact from floating drift or logs they shall be protected by timber crib work filled with loose rock or by other approved means.

They shall in no case be used as abutments to retain a fill.

FOUNDATION

Where the foundation material is soft, piles shall be driven to refusal called for in general specifications for "foundations," and be cut off below the water line. The tubes shall then be carried down to such a level that the top of the piles shall be buried in the concrete of the tubes a distance equal to two diameters of the tubes above their lower edge.

DEPTH

The bottom of the tubes shall be buried sufficiently below the existing river bed to preclude the possibility of scour.

ROCK FOUNDATION

Where rock is found, tubes will be anchored to it; or cribs may be sunk to rock, the tubes set in them to rest on it and the space between tubes and cribs be filled with concrete.

WEBS

Diaphragm webs will be used for river piers and extend well above the high water level.

CONCRETE CORE

Concrete filling in all tubes shall be of Class B mixture.

PIER CAPS

No special cap will be required, as the concrete, finished at the top, will form a satisfactory seat for the bridge shoes.

DIAMETERS

Minimum diameters of tubes for an over all height of 15 feet, to carry a single span, shall vary from 21 inches for a 50-foot span to 36 inches for a 175-foot span and these diameters shall increase three inches for each additional five feet in height. For piers carrying two spans, cross sectional areas shall be approximately twice the above areas.

SIZE OF PLATES

Plates shall be not less than one-quarter-inch thick for diameters up to thirty inches; five-sixteenths-inch from thirty inches to forty-eight inches, and three-eighths-inch for diameters from forty-eight inches to seventy-two inches. Where in contact with soil, the thickness shall be increased by one-sixteenth inch. Where necessary for stability, the minimum diameters mentioned above may be increased throughout the required depth of bottom section by offsetting.

JOINTS

Horizontal seams shall be single lap riveted with a pitch equal to four diameters of the rivet. Vertical seams shall be preferably butt riveted with single riveting, rivets spaced four diameters of rivet up to forty-eight-inch diameters, and double riveted with three-inch spacing for larger tubes.

STEEL BRIDGES

TYPES

Though subject to modification, due to local conditions affecting material and erection costs, the following data give the general adaptation of type to span:

Rolled beams	.... to 30 ft.
Rolled beams or plate girders	30 to 50 ft.
Low riveted trusses or plate girders	60 to 90 ft.
High Pratt trusses	100 to 140 ft.
High trusses, inclined chords	Over 150 ft.

DIMENSIONS USED FOR ESTIMATING

Length of span shall be taken as the distance between centers of end pins for pin connected and centers of shoes for riveted trusses. Length of floor beams is assumed as the distance center to center of trusses for suspended beams, and back to back of connection angles in the case of riveted trusses.

RATIO—DEPTH OF SPAN

Minimum in All Cases

Rolled beams	1 to 20
Trusses	1 to 10
Steel joists	1 to 33
Plate girders	1 to 12

WIDTH OF ROADWAY AND SIDEWALKS

The minimum width of roadway shall be 16 feet in the clear, and of sidewalks 5 feet.

HEADROOM

The distance from the bridge floor to the under side of portal or sway bracing shall not be less than 15 feet.

LOADS

Dead Load—Weight of materials entering into dead loads shall be assumed as follows:

	Lbs. per cu. ft.
Steel sections, as per handbook, or	490
Stone	160
Concrete	150
Brick	150
Macadam	130
Asphaltic wearing surface	135
Gravel	130
Earth fill or sand	120
Timber—	**Lbs. per bd. ft.**
Pine and fir (plain)	3½
Pine and fir (creosoted)	5
Oak	4½

Live Loads for Trusses—	Lbs. per sq. ft.
Medium Traffic—	
Trusses up to 150 ft. span	60
Trusses over 150 ft. span	50
Heavy Traffic—	
Trusses up to 150 ft. span	100
Trusses over 150 ft. span	75
Concentrated Loads (floor system)—	
Medium traffic	15-ton road roller
Heavy traffic	20-ton road roller

Note.—The 15-ton roller load is distributed as follows: ⅜ on the rear axle and ⅝ on front rollers; axles 10 feet apart, rear rollers 6-foot gauge.

The 20-ton load is distributed similarly: 7/10 on rear axle. 3/10 on front roller; axles 12 feet apart, rear rollers 6-foot gauge.

Wind—The top lateral bracing in deck bridges and bottom lateral bracing in through bridges shall be designed to resist a lateral wind load of 300 pounds per lineal foot, one-half of which is to be treated as moving load. The bottom lateral bracing in deck bridges and top lateral bracing in through bridges shall be designed to resist a lateral wind load of 150 pounds per lineal foot.

Bracing and columns for trestle towers shall be designed to meet a lateral pressure of 100 pounds for each vertical lineal foot of trestle bent, in addition to stresses due to vertical dead and live loads and lateral stresses from the trusses due to wind.

Temperature—Provision shall be made for a range in temperature of 100 degrees Fahrenheit.

Impact—To the maximum live load stress in each member shall be added an amount for impact determined by the formula:

$$I = \frac{100\ s}{L + 300}$$, where

I equals impact due to moving loads.

s equals live load stress.

L equals distance in feet over which the span is loaded to produce maximum live load stress in the member.

Impact shall not be added to stresses produced in the laterals by wind, nor in trusses or floor systems of heavy traffic bridges, loadings given having already provided for same.

UNIT STRESSES

TENSION

Medium steel and steel castings	16,000
Wrought iron	13,000

COMPRESSION

Structural steel, from 14,000 down to $16{,}000 - 70\frac{l}{r}$

l equals unsupported length in inches.
r equals least radius of gyration in inches.
$\frac{l}{r}$ shall not exceed 120 for main truss members.
$\frac{l}{r}$ shall not exceed 140 for lateral and other secondary members.

Cast steel	16,000

BENDING

Extreme fiber rolled sections, and built-up girders	16,000
Extreme fiber of pins	20,000

SHEAR

Shop rivets and pins	12,000
Field rivets and bolts	10,000
Webs of rolled or built-up beams, average gross section	10,000

BEARING

Shop rivets and pins	24,000
Field rivets and bolts	20,000

Expansion rollers in pounds per lineal inch equals diameter of roller in inches times 600.

REVERSE STRESSES

Members subject to alternate tension and compression shall be proportioned to resist each kind of stress, and for determining the net sectional area, the greater stress shall be increased by an amount equal to three-fourths of the lesser. Connections shall be proportioned for the arithmetical sum of the stresses.

COMBINED STRESSES

Members subject to combined direct and bending stresses shall be so designed that the greatest fiber stress shall not exceed the allowable unit stress for the member.

For stresses produced by lateral or wind forces in combination with those due to live and dead loads, a unit stress 25% in excess of that given above may be used; but the section shall be no smaller than that required if lateral or wind forces are neglected.

COUNTERS

Wherever live and dead load stresses are opposite in kind, two-thirds only of the dead load stress shall be considered as effective to counteract the live load stress.

FLOOR SYSTEM

FLOOR BEAMS

Floor beams shall be rolled or riveted steel girders, rigidly connected to trusses at panel points or to side girders, if used, and preferably at right angles to the line of the bridge.

JOISTS

Joists shall be of wood or steel, as specified. If of steel they shall be rigidly fastened to floor beams, and where the ends rest on masonry or concrete, steel wall plates shall be used. In the case of wood floors, steel joists shall be riveted to webs of floor beams by means of connection angles. If concrete floors are used, they may rest on top. The distance center to center shall not exceed three feet for wood floors.

Wood joists shall not be less than four inches wide nor sixteen inches deep and shall lap past each other over the full width of the floor beam flange. They shall not be spaced more than two and one-half feet center to center. Joists shall be bridged with a double row of three by four bridging, one line for from ten to twenty-foot spans and two lines for spans over twenty feet.

WOOD FLOORS

Wood floors shall be of edge grain pine or Douglas fir not less than four inches thick. Floor plank shall be laid at right angles to the direction of traffic, with spaces of approximately one-quarter inch between adjacent planks, and each plank shall be securely spiked with two seven-inch spikes to the nailing strips or joists.

Nailing Strips—For roadway from 16 to 20 feet wide, where the wood floor is carried on steel joists, there shall be four lines of nailing strips shimmed out from the webs of joists and bolted through the shims to the joists with ⅝-inch bolts at not to exceed 3-foot centers. One nailing strip shall be bolted to each outside joist and the other two shall be placed to form approximately equal intervals for the floor spikes.

Wheel Guards—Six by six wheel guards shall be provided on each side of the roadway. The guard will be held in place by ½-inch drift bolts, and spliced with 6-inch lap joints.

Sidewalk Plank—Sidewalk plank shall be not less than 2 inches thick, nor more than 8 inches wide, with ¼-inch openings between. At least two nailing strips shall be provided for each walk, and each plank shall be securely fastened to each such strip with 4-inch spikes.

Laminated Floor—Laminated floor shall consist of timbers laid up solid on edge, securely spiked to one another at 18-inch intervals, and shall have not to exceed two, and so far as possible, one length over the full width of roadway. Every fifth piece shall project one-half inch above the intervening four, to furnish grip for a waterproof wearing surface. The ends of timbers shall receive two thorough coats of some approved wood preservative.

CONCRETE FLOORS

Main Floor—Concrete in main floors where specified shall be of Class A concrete, screened aggregate, laid as to proportions and workmanship according to Standard Specification "B" of the State Highway Department, which follows. Such floors shall be of best standard design, of thickness and reinforcement necessary to meet the loadings of "Heavy Traffic," as herein specified. Transverse rods shall extend four inches into the wheel guard or curb hereinafter described. The concrete shall be rough finished by tamping and shall include waterproofing of an approved nature.

Sidewalks—Sidewalk slabs shall be of Class A concrete, similar to the main floor.

Curbs and Wheel Guards—Concrete wheel guards or curbs standing 12 inches above the roadway slab shall be provided on each side and be protected by an approved galvanized metal curb bar.

DRAINAGE

All parts of the floor shall drain satisfactorily, and the water shall be carried clear of all metal work.

DETAILS OF DESIGN

MINIMUM THICKNESS OF METAL

No material shall be less than 5-16 of an inch in thickness, except that used for fillers and other minor parts; but a less thickness may be used for webs of I-beams and channels by modification, as a supplementary clause to the specification, when made by the Engineer in writing before the contract is awarded.

In case of compression members built up of rolled sections and a cover plate, if there be an excess of strength in the member not less than 25% of the calculated amount, then cover plates may be reduced to ¼ inch in thickness.

ACCESSIBILITY

Structures shall be designed to facilitate, so far as possible, the inspection, cleaning and painting of material after erection.

CAMBER

Truss spans shall be cambered by increasing the panel lengths of the top chords, or their horizontal projections, to 3-16 of an inch longer than the corresponding panels of the bottom chords for each ten feet of length of panel.

EXPANSION AND CONTRACTION

For beam and girder bridges, expansion bearings shall be designed to permit motion by sliding. For truss bridges, rollers or rockers shall preferably be provided—rollers to have a minimum diameter of 3 inches, which shall be increased in the proportion of one inch for each 100 feet of span in excess of 100 feet. The pressure per lineal inch on rollers shall not exceed 600 times the diameter of the roller in inches. All expansion bearings shall be designed to permit motion in a longitudinal direction only.

SHOES OR BOLSTERS

All bridges 100 feet or more in length, whether pin connected or riveted, shall have pin shoes at the ends. Shoes or bolsters shall be so designed that the load will be distributed over the entire bearing and shall be securely stayed by anchor bolts against lateral movement.

ANCHORS

There shall be at least two roughened or swedged anchor bolts through each shoe not less than one inch in diameter and 18 inches long for spans up to 150 feet, and 1¼ inches in diameter and 18 inches long for spans of 160 feet and over.

BED PLATES

Bed plates shall be so proportioned that the pressure upon masonry or concrete shall not exceed 400 pounds per square inch.

NET SECTION AT RIVETS

In proportioning tension members the diameter of the rivet holes shall be taken ⅛ inch larger than the nominal diameter of the rivets, and net sections shall always be used.

CONNECTIONS

All connections shall be designed to develop the full strength of the connecting members.

The neutral axes of connecting members shall meet in a point.

RIVETS AND RIVET SPACING

Diameter—Rivets shall be ⅞-inch, ¾-inch or ⅝-inch diameter, except when used in minor parts. Unless otherwise permitted, ⅝-inch rivets shall be used for flanges less than 2½ inches wide; ¾-inch rivets for flanges between 2½ and 3½ inches, and ⅞-inch rivets for all flanges over 3½ inches wide.

Pitch—At the ends of built compression members, the pitch of rivets in the line of stress shall not exceed four diameters for a distance equal to twice the maximum width of the member.

Grip—The grip of rivets shall in general be not greater than four diameters. Where it is necessary to make it greater than four diameters, the allowable unit shearing stress shall be decreased 1 per cent for each 1-16 inch of additional grip.

Edge Distance—The minimum distance from the center of any rivet hole to a sheared edge shall be 1½ inches for ⅞-inch rivets; 1¼ inches for ¾-inch rivets, and 1⅛ inches for ⅝-inch rivets.

For rolled edges, except flanges of I-beams and channels, use 1¼ inches for ⅞-inch rivets; 1⅛ inches for ¾-inch rivets, and 1 inch for ⅝-inch rivets.

COMPOSITION OF SECTIONS

Top chords, end posts and other unsymmetrical sections composed of two rolled or built-up channels and a cover plate, shall be proportioned to bring the center of gravity as near as possible to the center of the web, and in all compression members the metal shall be concentrated so far as practicable in the webs and flanges.

COVER PLATES

Cover plates shall have a thickness of not less than 1-40 the distance between rivet lines.

PIN CONNECTIONS

All pins shall be sufficiently long to furnish full bearing upon the turned body of the pin for all connecting parts. They shall be secured by chambered nuts and the screw ends shall be long enough to admit of burring the threads after the nuts are set.

No pin shall have a diameter less than three-quarters the width of the widest eye-bar attached to it.

The several members attaching to a pin shall be so placed upon it as to produce the minimum bending moment. All members shall be held in place upon the pin by filling rings.

The diameter of the pin hole shall be not more than 1-32 of an inch greater than the diameter of the pin.

Pin holes shall be so reinforced as to distribute the stresses properly over the full cross section of the members. Where pin plates are used, at least one plate on each side shall extend not less than 6 inches beyond the edge of the nearest batten plate.

Pin connected riveted tension members shall have a cross-sectional area through each pin hole 25% in excess of the net sectional area of the members. Between the pin hole and the end of the metal, the sectional area of the metal shall not be less than 75% of the sectional area through the pin hole.

HIP VERTICALS

Hip verticals of all trusses shall be stiff members.

BATTEN PLATES

The open sides of compression members shall be stayed by batten plates at their ends, and at intermediate points by lattice bars.

When for any reason the latticing is interrupted, batten plates shall also be used as at the ends.

Batten plates shall have a thickness of not less than ¼ of an inch nor 1-50 the distance between the lines of rivets connecting them to the flanges. Near the ends of chord members they shall have a width parallel to the axis of the member of not less than the distance between lines of rivets connecting them to those members. At all other points the width shall be not less than three-quarters the distance between rivet lines as above.

LATTICE BARS

Lattice bars shall have a thickness of not less than ¼ of an inch nor less than 1-50 of their unsupported length.

They shall be inclined to the axis of the member at an angle not less than 60 degrees for single lacing, nor less than 45 degrees for double lacing. Double lacing shall be riveted at points of intersection.

The width of lattice bars shall not be less than 1½ inches nor less than ⅛ the width of any member of which they form a part. The ends of lattice bars shall be neatly rounded.

ABUTTING ENDS

Abutting ends in compression members shall be planed true to the angle of the joint and sufficiently spliced on four sides to hold the connecting parts accurately in place. All joints in tension members shall be fully spliced.

EYE BARS

Thickness of eye bars shall be not less than ⅝ inches nor less than 1-7 the width of the bar. Adjacent bars shall be so arranged that their surfaces are not in contact. The inclination of individual eye bars to the axis of the member which they compose shall not be greater than 1 inch in 16 feet.

RODS

No rod shall be used which has a cross-sectional area less than ¾ of a square inch.

ADJUSTABLE MEMBERS

Adjustable members shall, so far as possible, be avoided.

COMPRESSION MEMBERS

Compression members shall be so designed that any part or segment of a member will be proportionately as strong as the member taken as a whole. No web shall have a thickness less than one-thirtieth the distance between the lines of rivets connecting it to the flanges.

Flanges of built members which have no cover plates shall have a thickness not less than one-twelfth the width of the outstanding leg.

LATERAL SYSTEM

All lateral, portal and sway bracing shall be made of shapes capable of resisting both compression and tension, and shall have riveted connections to the chords.

LATERALS

Laterals shall be as nearly in the plane of the axes of the chords as practicable. When eccentricity is unavoidable, provision shall be made for the maximum bending stresses which would be produced in the connections with the member fully loaded.

PORTALS

Portals for through bridges shall be as deep as the specified headroom and depth of truss will permit, and shall be constructed of top and bottom struts and stiff intermediate bracing. All portals shall be provided with knee or corner braces.

STRUTS

Intermediate top struts in through bridges shall have a depth not less than that of the top chord, and where necessary shall be provided with knee or corner braces.

SWAY BRACING

Deck bridges and through bridges, where long spans and consequent height of truss require it, shall have sway bracing in the case of deck bridges to the full depth of trusses

and for through bridges to leave only the same headroom as for the portals. At the end of trusses, ample provision shall be made for transferring all wind loads to the piers or abutments, and in the case of through bridges, the end posts shall be designed to take the bending moment due to wind stresses transmitted from the portals.

LOW TRUSS CHORD STIFFENING

For low trusses, to insure lateral stability, top chord sections shall preferably be of the wide cover plate and spread angle or channel type, with wide webbed, well-stiffened posts attached rigidly to the chord above and the floor beam below.

HAND RAILS

A substantial hand railing not less than 3½ feet high and of appropriate design, shall be constructed on the outside of foot walks or when foot walks are omitted, at the outside of the roadway.

DRAINAGE AND POCKETS

The design shall provide, so far as practicable, to avoid pockets or depressions which might contain water and where these occur drain holes shall be placed or pockets be filled with waterproof material.

PLATE GIRDERS

PROPORTIONING

The flanges shall be assumed concentrated at their centers of gravity and one-eighth of the gross section of the web, if properly spliced, may be used as flange section. The flanges shall be assumed to take all bending moment and the web all shear.

WEB THICKNESS

The thickness of web plates shall be not less than 1-160 of the unsupported distance between flange angles, and in no case less than 5-16 inches.

WEB SPLICES

Web plates must be spliced at all joints by a plate on each side of the web, designed to transmit the full shear through the splice rivets.

WEB STIFFENERS

Stiffeners must be used at intervals not exceeding the depth of the girder nor a maximum of 5 feet wherever the shearing stress per square inch exceeds that given by the formula (S equals 12500—90H), where S equals shear and H equals ratio of web depth to thickness.

FLANGES

Through plate girders shall preferably have their upper corners neatly rounded and if flange plates are used, one plate of the upper flange shall extend over the corners to the bottom of the girder at either end.

The compression flange shall have the same gross section as the tension flange.

Through plate girders shall have their top flanges stayed at every floor beam, or in case of solid floors at not to exceed 12-foot intervals, by knee braces or gusset plates.

WEB DESIGN

Web plates of girders which have no cover plates shall be flush with the backs of angles. Where cover plates are used, ¼-inch clearance shall be provided between edge of web and back of flange angles.

When web plates are spliced, not more than ¼-inch clearance between adjacent plates will be allowed. Splice plates and fillers under stiffeners shall be cut to fit within ⅛ inch of flange angles.

Stiffeners shall be designed for the maximum vertical shear with a unit stress not to exceed $16000 - \frac{70\,l}{r}$, where r equals radius of gyration of stiffeners at right angles to the web and l equals one-half depth of girder, both in inches.

Each stiffener shall be connected to the webs by enough rivets to transfer the maximum shear to or from them, and shall bear tightly against upper and lower flanges.

WIND BRACING

At each end of the span a floor beam shall be placed, capable of resisting the accumulated wind pressure.

FLANGE PLATES

Flange plates shall not extend beyond the outer lines of rivets, connecting them to the angles more than eight times the thickness of the outside plate, and in no case more than 5 inches. If two or more plates are used, the thickness shall decrease outward from the angles. Where flange plates are used, one cover plate of the top flange shall extend the whole length of the girder and at least one-half of the flange section shall be angles; or else the largest sized angles must be used. Flange plates must extend beyond their theoretical length two rows of rivets at each end.

FLANGE RIVETS

Flanges shall be connected with rivets, sufficient in number to transfer the total shear at any point, combined with any load applied directly to the flange at that point in a distance equal to the effective depth of the girder.

Rivet spacing in the vertical legs of flange angles shall be determined by the formula $p = \frac{r\,h}{s}$, where p equals the pitch in inches, r the permissible stress in one rivet in pounds, h the distance between rivet lines of top and bottom flanges in inches, and s the maximum shear in pounds at the section under consideration. In no case, however, shall the pitch exceed 5 inches.

CONCRETE BRIDGES AND CULVERTS

STANDARD PLANS

Standard plans for concrete box culverts, slab and girder bridges and typical concrete arches will be furnished by the State Highway Department on request, free of charge to the Counties, to supplement and interpret the requirements of these specifications.

ROADWAY

For ordinary conditions of traffic the minimum width of finished roadway should be not less than 16 feet in any case; preferably 24 feet for box and arch culverts of from 2 to 16 feet span, and 20 feet for slab bridges of from 16 to 25 feet span, and for arch bridges above 16 feet span.

For determining the lengths of culverts and bridges under fills, side slopes shall be taken at one and one-half horizontal to one vertical.

PERMISSIBLE UNIT STRESSES

For reinforced concrete bridges the permissible stresses shall be as follows, and under no circumstances shall concrete be designed to resist tension:

	Lbs. per sq. in.
Compression Class A Concrete—	
Reinforced girders	650
Plain and reinforced arches	600
Shear in concrete, no reinforcement	40
Shear in concrete, suitable bent-up bars	60
Shear in concrete (with reinforcement provided for shear in excess of 40 lbs.)	120
Tension in reinforcing steel	16,000
Bond between reinforcing steel and concrete surface area	80
Bearing of bridge shoes	600

EXPANSION AND CONTRACTION

Temperature stresses shall be calculated for a range of 40 degrees either way from normal in all reinforced concrete work, including concrete arch construction, excepting only the three-hinged type.

Slabs will not be considered free to expand and contract when separated from foundation walls by paper, felt, tar, or asphalt joint alone.

Reinforced concrete girders shall have rocker or other bearings of nominal friction, the superstructure being separated from substructure at all points by open joint or joints not less than ¼ inch thick, filled with bituminous felt.

CAMBER

Single span girder and slab bridges shall be given a permanent camber of at least 1-20 inches per foot of clear span, while for two or more spans the bridge shall be given a rise at the center of not less than 1-20 inches per foot length of structure.

WATERPROOFING

Floors for slab and girder bridges shall be rough finished and either coated with an approved hot bituminous coating or be finished with a suitable bituminous wearing surface. This shall apply to arch bridges having concrete floors.

For arch bridges of the closed spandrel type, designed to carry earth fill on arch rings, either plain or tied into arch ribs, the top of the arch ring and ribs and lower six inches of the spandrel walls on the inside shall be brought to a reasonably smooth surface with a coating of rich cement mortar and then be covered with a neat cement grout or bituminous coating.

DRAINAGE

Floors of slab and girder bridges and of arch bridges, if of concrete, shall be drained by pipe drains or openings in the floor, toward which the surface shall be made to slope. For spandrel arches with earth fill, drainage shall be provided at the back of the arch at each pier abutment by pipe drains.

CULVERTS

Spans under 16 feet may, if the foundations require, be built without footings, but with a heavily reinforced floor distributing the pressure on the foundation. The floor or footings of slab culverts under heavy fills shall be designed to distribute the pressure over the full length of the foundations by longitudinal reinforcement.

Where reinforced floors are used across the stream bed, cut-off walls should be used at each end of the floor.

Where subject to the action of a swift current or heavy floods, the floors should continue to the end of the wings on the down stream side with cut-off wall as above required.

PILING

Piling may be used for concrete bridges and arches if of moderate spans and on fairly good bearing soils, provided other suitable foundation is not to be had. This piling shall be used under conditions specified for "Foundations."

ARCH DESIGN

GENERAL CALCULATIONS

Arches shall be designed by the elastic theory. Stresses in the ring shall be computed for the entire dead load; for live load covering the entire span; for live load covering 6-10 the span; for filled spandrels; for live load local concentration for open spandrels; for temperature stresses, and for stresses due to shortening of rib.

STEEL REINFORCEMENT

The area of metal at the crown shall be not less than ⅔ of 1 per cent.

Arch reinforcement shall be of the double and preferably of the symmetrical type, and no tension shall be assumed to be taken by concrete in the arch ring.

GENERAL NOTES

VIADUCT COLUMNS

In general the unsupported lengths of viaduct columns shall not be greater than 15 times the least diameter or side. These columns shall be designed first to be reinforced longitudinally, and to be hooped circumferentially according to the best standards of reinforced concrete practice.

The unsupported length of plain concrete columns shall not exceed eight times the diameter or least side.

Provision shall be made in all cases for eccentricity of loading.

CONTINUOUS BEAMS

Where beams, girders or slabs are continuous over three or more supports and sufficiently reinforced, the maximum bending moment at center of intermediate span shall be

$$M = \frac{wl^2}{10} \text{ for uniform loads and } M = \frac{wl^2}{9} \text{ for end spans.}$$

T-BEAMS

Where there is sufficient bond between slab and beam the part of the beam below the slab, together with part of the slab, may be considered to act as a T-beam.

In this case the total effective width of flanges shall be taken at not to exceed four times the thickness of slab plus width of stem, nor shall it exceed one-quarter the total span.

TIMBER BRIDGES AND TRESTLES

UNIT STRESSES

The following safe working unit stresses shall be used for all structures built of Dougas fir or equal:

	Lbs. per sq. inch
Tension	1,200
Compression	$1{,}200\left(1-\frac{L}{60\,d}\right)$

where L equals unsupported length in inches and d equals dimension of least side.

End bearing	1,200
Bearing at right angles to the grain	400
Shear parallel to the grain	200

WOOD TRUSSES

In general, the chords shall have the same gross sections throughout their lengths as determined by the stresses due to maximum bending moments at the center.

Joints shall be so detailed as to remain so far as possible rigid and of such design that failure would occur in the main members first.

Bearings of all struts shall be true and ample, and where wood bears on metal the ends of the members shall be treated or protected against decay.

Splices shall be so designed that failure will occur in the main members, if at all.

The lateral system shall be so detailed that the members composing it will not be displaced in case shrinkage in timbers occurs.

For Howe trusses and other built-up members, standard packing blocks shall be used to distribute the stress uniformly throughout the members.

All through wood trusses shall preferably be housed.

Counters shall be used whenever conditions of span and loading so require.

Floors shall be designed as under specifications for Steel Bridges.

For all high bridges portal, sway or side braces shall be provided, as also suitable hand rail.

Iron or steel washers shall be used for all bolts throughout the structure, and at the ends of all rods where not otherwise detailed.

At the bearing of inclined end posts on bottom chords the latter shall be sufficiently long to provide ample shearing strength parallel to the grain between the point of contact and end of chord.

The walls and railing of all housed bridges shall be whitewashed.

WOOD TRESTLES

DESIGN

Pile trestle bents shall in general be of four-pile construction, with 12x12 caps, double 3x10 diagonal braces and 3x10 double sash.

Where height of deck above ground is less than 32 feet, single sets of diagonals will be sufficient. In excess of that height, bracing shall be separated into two vertical panels, with horizontal sash consisting of two 3x10 timbers, between.

Longitudinal bracing, consisting of one piece of 4x10, butt jointed at the bent and bolted to it, shall be provided where the height of deck above the ground is more than 24 feet.

Where squared timber bents are used they will be framed of four 12x12 uprights, the outside sticks as for the pile bents, to have a batter of 1½ inches per foot, wherever their length is greater than 12 feet.

Mud sills shall be 12x12 timbers, resting either on pile foundations, or concrete pedestals in firm ground.

For temporary construction, mud sills may be carried on wood blocking, laid on firm ground and sufficiently high to leave the sill clear of the underlying surface.

Caps shall be drift bolted to uprights and mud sills to piles below them, with bolts ¾ inches in diameter by 24 inches long. Squared uprights shall be bolted to mud sills with suitable ¾-inch bolts.

Diagonal braces shall be spiked to intermediate uprights with 7-inch spikes and their ends bolted to the outside posts or piles, caps or mud sills with ¾-inch bolts. Horizontal sash shall be bolted at their ends and spiked at intermediate points to the uprights.

Wood hand rails shall be provided with tops 3 feet 6 inches off the floor and have a combined 2x4 and 2x6 top rail, a 2x8 hub-guard and 4x6 posts, all material to be S4S.

Posts shall be two to the panel or bent interval, which in general shall be 19 feet to permit the use of 20-foot joists. Posts shall be double bolted to outside joists.

The floor system will be provided under the specification for wood floors in steel bridges. Outside joists to be butt jointed; inside to lap.

Where subject to overflow and upward pressure from below, the floor system of approaches shall be tied down to the bents and the bents to foundations by suitable anchorage.

All bolts shall have iron washers under nuts and heads.

Piling shall be assumed with a penetration of 15 feet in firm ground for approach and other land work; for river work, assumed penetration shall be based on the best data available as to the nature of river bed. In both cases, actual penetration will be modified to suit conditions under requirements of Foundation Piling, Specification "B."

PROPOSED BRIDGE SITE—JOHN DAY RIVER AT MACDONALD, COLUMBIA HIGHWAY

Photo No. 9

MEDIUM TRAFFIC BRIDGE—322 FEET SPAN Photo No. 10

PROPOSED BRIDGE SITE—JOHN DAY RIVER AT MACDONALD, COLUMBIA HIGHWAY Photo No. 9

MEDIUM TRAFFIC BRIDGE—322 FEET SPAN Photo No. 10

STANDARD SPECIFICATIONS "B"

FOR ADVERTISEMENT, PROPOSAL, CONTRACT, BOND, GENERAL STIPULATIONS

AND

MATERIAL, WORKMANSHIP AND ERECTION OF

BRIDGES

OREGON
STATE HIGHWAY
COMMISSION
1916

SPECIFICATIONS "B"

INTENT

The object in here presenting the following Specifications "B," which includes advertising, proposal, contract, bond and general stipulation forms, is solely for the purpose of getting straightforward, easily understood agreements which aim to minimize dispute and evasion, and further seek to secure good work as cheaply as possible to the counties concerned.

PROPOSAL FORM

The proposal form shown is typical and is intended to indicate in a general way the clauses necessary to adequately provide for additions and deductions to various classes of work. It further shows how, in case the nature of the work permits, bids may be advantageously segregated to cover different classes of construction and then brought together either as a whole or in part at a probably lower figure than the sum of the individual parts.

SURETY BOND

The law requires that the amount of the bond shall be at least 50 per cent of the contract. This amount, however, should be made absolutely dependent on the risk attendant on the construction work involved since, although the contractor is, by the specification, held liable for damages to the full amount, the bondsman is liable only for the amount of his bond. In many repair jobs the total amount of the contract is small compared with the value of the existing structure exposed to injury or collapse by the contractor's operations. These risks should be covered.

SPECIFICATIONS (Special to the Contract)

Following the general standard specifications is a typical additional sheet, giving an example of special clauses particular to the structure, which has been assumed for purposes of illustration. This special specification will contain more or less information than that shown, depending on the nature and extent of the work.

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STATE OF OREGON
COUNTY OF.....

NOTICE TO CONTRACTORS

PROPOSAL

Sealed proposals, addressed to the County Court of..... ..... County, Oregon, and endorsed "Proposals for Constructing a Bridge in..... County, Oregon, over....." will be received by the County Court of said County at its office in the courthouse,..... Oregon, until 2:00 o'clock p. m., on the..... day of....., 191....., and at that time and place will be publicly opened and read.

FORMS

All proposals must be made upon blank form to be obtained from the County Clerk, at his office at the courthouse, ..., Oregon; must give the prices proposed, both in writing and figures; and must be signed by the bidder, with his address.

BIDDER'S BOND

Each bid is to be presented under sealed cover, and shall be accompanied by cash, a bidder's bond made payable to ....., County, or a certified check made payable to the County Clerk of said County, for an amount equal to at least five per cent of the amount of the said bid, and no bid shall be considered unless such cash, bond, or check is enclosed therewith. Such bidder's bond shall be conditioned that if said bid be accepted, the party bidding will duly enter into and execute the contract. Should the successful bidder to whom the contract is awarded fail to execute the same within ten days (not including Sunday) from the date of the mailing of the notice from the County Court to him, according to the address therewith given, that the contract is ready for signature, such cash, bond or certified checks shall be forfeited to.....County, and the same shall be the property of the county. All other cash, bonds, and certified checks will be returned to the unsuccessful bidders who submitted the same.

SURETY BOND

A corporate surety bond will be required for the faithful performance of the contract in a sum equal to one-half of the total amount bid.

PLANS AND SPECIFICATIONS

Plans may be seen and forms of specifications and contract may be secured at the County Clerk's office, courthouse, ..., Oregon, or at .....

PLAN DEPOSIT

A deposit of $5.00 will be required for plans and specifications. Deposit will be returned to each bona fide bidder.

REJECTION OF BIDS

The right is reserved to reject any or all proposals or to accept the proposal or proposals deemed best for..... County.

COUNTY COURT of.....COUNTY,
....., County Judge.
....., County Commissioner.
....., County Commissioner.
....., County Clerk of
..... County.
....., Oregon, ...

PROPOSAL

To the County Court of.....County, Oregon, for constructing a bridge in.....County, Oregon, over.....River, at..... Street,.....

To the County Court of.....County:

The undersigned, as bidder, declares that the only parties interested in this proposal as principals are those named herein; that this proposal is made without collusion with any other person, firm or corporation; that he has carefully examined the location of the proposed work, the annexed proposed form of contract, and the plans therein referred to; and he proposes and agrees, if this proposal is accepted, that he will contract with.....County, in the form of the copy of the contract annexed hereto, to provide all necessary machinery, tools, apparatus and other means of construction, and to do all work and furnish all the materials specified in the contract, in the manner and time therein set forth, and that he will take in full payment therefor, sums according to the following schedule:

Proposal No. 1

For furnishing all material and labor required for the construction of the foundations and steel bridge over the .....River complete as shown on drawings Nos. 383, 385, and 389, including erection and painting, the sum of.....Dollars ($.....) lump sum bid.

Proposal No. 2

For furnishing all material and labor required for the construction of the same foundations as proposal No. 1, together with a wood span, in place of steel, all as shown on drawings Nos. 383, 385, 387, and 388, the sum of .....Dollars ($.....) lump sum bid.

Proposal No. 3

For furnishing labor and materials required for the construction of a concrete bridge over the S. P. tracks alone, complete as shown on drawings Nos. 383 and 386, the sum of .....Dollars ($.....) lump sum bid.

Proposal No. 4

For furnishing and erecting wooden approaches at both ends of main span across the.....River, complete as per drawings Nos. 383, 384, and 394, the sum of .....Dollars ($.....) lump sum bid.

Proposal No. 5

For furnishing material and labor for the crossing complete, including foundations, steel span, overhead concrete viaduct and wood approaches, all as called for on drawings

Nos. 383, 384, 385, 386, 389, and 394, including erection and painting of steel, the sum of.....Dollars ($.....) lump sum bid.

Proposal No. 6

For furnishing material and labor for the crossing complete, except that for the steel span of drawing No. 389 a wooden span will be substituted as shown on drawings Nos. 387 and 388, the sum of.....Dollars ($.....) lump sum bid.

Proposal No. 7

For any addition to or deductions from Class C concrete in bases of substructure for main span over..... River, including cofferdam, excavation and back fill, the sum of.....Dollars ($.....) per cubic yard.

If the amount of concrete in the bases is changed from that shown on the original drawings and for which the above lump sum price is bid, then such lump sum price shall be reduced or increased, as the case may be, in accordance with this unit price, and the reduced or increased yardage. It is hereby agreed that no variation in depth from the original plan greater than five feet would be required under this unit price bid.

Proposal No. 8

For any additions to or deductions from Class B concrete above the bases the sum of.....Dollars ($.....) per cubic yard.

If the amount of concrete in the piers above the bases is changed from that shown on the original drawings, and for which the above lump sum price is bid, then such lump sum price shall be reduced or increased, as the case may be, in accordance with this unit price, and the reduced or increased yardage.

Proposal No. 9

For any additions to or deductions from excavation work in foundations other than that involved in change in the size of the base itself, as provided in proposal No..... the sum of.....Dollars ($.....) per cubic yard, including cofferdam work, pumping and back fill.

This proposal is based on the assumption that the contract profile drawings give the desired elevation of the foundation base in relation to the lowest point of contact of the undisturbed river bottom with the side of said base, and that the limits of change shall be five feet either way.

Proposal No. 10

If the penetration of piles in the approaches on the west bank be changed from that shown on the plans, within the limits of five feet either way, add to or deduct from the contract amount of Proposals Nos. 1, 2, and 7, the sum of .....cents per lineal foot of change without claim of any kind for waste material or other loss.

Proposal No. 11

For additions to or deductions from the penetration of piling in the foundation for the west pier, as shown on the plans, add to or deduct from the lump sum price of Proposals Nos. 1 and 2 the sum of.....cents per lineal foot of change, with no allowance for waste material, within the limits of variation of five feet either way. For variation in excess of five feet either way, compensation to be allowed the contractor as an addition to the above extra in case of increased penetration or as a partial offset to his reduction in case of decreased penetration, as the case may be, for waste pile material, the amount of said addition or offset being determined solely by the Engineer under the specifications; and provided further,

That this bidder agrees that before any piles which are to remain in the completed structure are ordered or driven, he will determine, so far as possible and to the satisfaction of the Engineer, the working length required, by driving a sufficient number of test piles for this purpose, and in case of failure to do this, piles ordered by him of insufficient length for driving shall be at his risk.

Accompanying this proposal is a certified check in the sum of.....Dollars ($.....), equal in amount to five per cent of the total of the bid.

If this proposal shall be accepted and the undersigned shall fail to contract as aforesaid, and to give the bond in the sum of one-half of the total amount of the contract as aforesaid, with security satisfactory to the County Court of .....County, within ten days (not including Sunday) from the date of the mailing of the notice from the County Court to him, according to the address herein given, that the contract is ready for signature, the County Court of.....County may, at its option, determine that the bidder has abandoned the contract, and whereupon this proposal and the acceptance thereof shall be null and void, that the forfeiture of such security accompanying this proposal shall operate and the same shall be the property of.....County.

Signature of bidder.....

Business address.....

Place of residence.....

Date....., 1916.

The full name and the residence of all the persons and parties interested in the foregoing proposals as principals are as follows:

(Note.—Give first and last names in full; in case of corporations, give names of president, treasurer and manager, and in case of partnerships, give the names of the individual copartners. No proposal will be considered unless executed in ink.)

.....

.....

.....

.....

.....

STATE OF OREGON
COUNTY OF.....

CONTRACT

For constructing .....

This agreement, made and entered into, in triplicate, this .....day of....., A. D. 191....., between.....County, Oregon, by its County Court, party of the first part, and..... part..... of the second part.

Witnesseth, That the said part..... of the second part, in consideration of the sums to be paid to..... by.....County, in the manner and at the times hereinafter provided, and of the other covenants and agreements herein contained, agree..... to and with the party of the first part, that .....he..... will construct the following structures:

SCOPE

.....

according to the Plans and Specifications furnished and the Proposal hereto annexed and made a part hereof; that .....he..... will furnish all material, and all labor necessary to complete the above described work strictly in accordance with said Specifications and General Stipulations hereto attached, and in accordance with plans of said bridge on file in the office of the County Clerk of..... County, at....., Oregon.

CONTRACT DOCUMENTS

It is further agreed, that the Plans, Proposal, Contractors' Bond, Specifications and General Stipulations shall be a part of this contract, and have the same force and effect as though all of the same were fully inserted herein.

ENGINEER TO SUPERVISE

All of said work is to be done under the supervision and direction of the Engineer selected by..... Said Engineer shall have the right to fully decide on all questions arising as to the proper performance of said work, and his decision shall be conclusive and binding on all parties hereto.

DISCONTINUANCE OF WORK

If at any time the Engineer shall be of the opinion, and shall so certify in writing, that the work under this contract, or any part therof, is unnecessarily delayed, or that said Contractor is wilfully violating any of the conditions or covenants of this contract, or is executing the same in bad faith, or if the said contract be not fully completed within

the time named in this contract for its completion, he shall have the power to notify the aforesaid Contractor to discontinue all work or any part thereof under this contract by written notice to be served upon the Contractor and thereupon the said Contractor shall discontinue said work. And ten days after such notice is served the County shall have the right to undertake the completion of such work either by force account or by letting the contract to other parties. Any increase or decrease in the cost of work so done compared with the amount that would have been paid the Contractor for it, shall be deducted from or added to any amounts still due him or covered by the Surety Bond. Under these circumstances the County shall have the right to enter upon and take temporary possession of the plant, tools, materials and supplies of the Contractor or any part thereof which it may deem necessary for the prosecution of such work. Plant and tools and unused material and supplies shall be returned to the Contractor at completion, provided that in case the cost of the work taken over exceeds that which would have been paid the Contractor for it under his contract, by an amount greater than the moneys still due him, tools and plant may be sold by the County sufficient to cover any deficit, and on all matters of adjustment under this heading the decision of the Engineer shall be final and conclusive on all parties.

TIME OF COMPLETION

Said work shall be completed on or before.....; provided, however, that in case of extraordinary emergency, such as flood, fire, or similar act of Providence, the Engineer may, upon request of the part.... of the second part extend the time for the completion of the work under this contract without invalidating any of the provisions herein contained.

LIQUIDATED DAMAGES

It is further agreed by the parties hereto that in case all the work called for under this contract, in all parts and requirements, is not finished or completed on or before ....., damage will be sustained by the said county, and that it is and will be difficult and impossible to ascertain and determine the actual damage which the county will sustain in the event of and by reason of such delay; and it is therefore agreed that said Contractor will pay (as liquidated damages and not as a penalty or forfeiture) to the County the sum of..... dollars per day for each and every day's delay beyond the time herein prescribed in finishing the said work and said Contractor agrees to pay said liquidated damages as herein provided, and in case the same is not paid, agrees that said County Court may deduct the amount thereof from any money due or that may become due said Contractor under this contract.

If the Contractor fail to complete the work within the time specified and if the County shall nevertheless permit said Contractor to proceed, continue and complete the same as if such time had not lapsed, such permission shall not modify nor waive in any respect any forfeiture or liability of the Contractor for damages arising under the Liquidated Damages clause of the Specifications, but such liability shall continue in full force against the Contractor as though such permission had not been granted.

PAYMENTS

The expense of the construction of said bridge shall be paid by the County Treasurer upon warrants of the County Clerk, issued upon the vouchers of the said Engineer which have been approved by the County Court, out of the moneys on hand for such purposes.

Partial payments on said contract not to exceed seventy-five per cent (75 per cent) of the value of the portion of the structure completed or material on the ground which is to be finally incorporated in the finished work and remain as a part of the structure, shall be made at the request of the Contractor once each month, said payments to be based upon the estimates of the Engineer in charge of said work. The Engineer may at his discretion allow partial payments for temporary construction in advance of the permanent work, as materials for falsework and forms are employed, but the Contractor shall have no right to demand such compensation. No payments shall relieve the Contractor of responsibility for defective materials or workmanship.

If the Contractor fail to complete the work within the time specified, no partial estimates will be rendered and no payments will be made after the date specified for completion until the Contractor shall deliver to the Engineer prior to each and every such partial payment the written consent of the Contractor's Surety permitting such payment to be made without affecting the validity of the bond—or unless a request to the Engineer shall have been made in writing by both the Contractor and his surety for an extension, which request shall have been granted in writing by the Engineer with the approval, also in writing, of the County. Such extension to cover the period of any payments in question.

FINAL ESTIMATES

The Engineer shall, as soon as practicable after the completion of this contract, make a final estimate of the amount of work done thereunder, and the value of such work, and the county shall, at the expiration of thirty-five (35) days from and after such final estimate is so made, and is approved by the County Court, pay the entire sum so found to be due hereunder, after deducting therefrom all previous

payments and all amounts to be retained under the provisions of this contract. All prior partial estimates and payments shall be subject to correction in the final estimate and payment.

SURETY BOND

It is further agreed that the part.... of the second part shall, within ten days (not including Sunday) from the date of the mailing of the notice from the County Court to .....
according to the address given in the proposal annexed hereto, that the contract is ready for signature, and before commencing the work hereunder, furnish to said County Court, a corporate Surety Bond in the sum of..... Dollars ($.....), for the faithful performance of this contract in all respects, and this contract shall not be binding until said bond is so furnished and approved by the County Court, and if not so furnished within the ten days herein specified, this contract shall be immediately terminated without any notice or further action by either party.

LABOR AND MATERIAL BILLS

It is further agreed by and between the parties hereto and as a condition hereof that the Contractor shall promptly make payment for labor and material at such times as they may become due and payable to all persons supplying said Contractor with labor or material for the prosecution of the work provided for in this contract, and that said Contractor will not and shall not permit any lien or claim to be filed or prosecuted against the State of Oregon, the County of ....., or any officer, agent or employe thereof for or on account of any labor or material furnished.

INJURIES TO PERSONS OR DAMAGE TO PROPERTY

Materials paid for by the County shall be considered to have been delivered to and become the property of said County, but neither the County nor any officer thereof, the Engineer, nor any authorized assistant of the Engineer, either personally or in their official capacities, will, during the continuance of this agreement, in any manner be answerable or accountable for any loss or damage that shall or may happen to the said work or any part thereof, respectively, or for any of the materials or other things used or employed in finishing and completing said work, or for injury to any person or persons, either workmen, or the public, or for damage to adjoining property from any cause which might have been prevented by the Contractor or his workmen, or by any one employed by him; against all of which injuries or damages to persons or property, the Contractor having control over such work must properly guard.

And said Contractor further agrees that he will be responsible for any damage to any person or property resulting from defect or obstructions, or from any cause whatsoever, during the progress of the work, or at any time before its completion and final acceptance, and that he will indemnify and save harmless the county, and any officer thereof, the Engineer, and any authorized assistants of said Engineer, from all suits or actions of every name and description brought for or on account of any injuries or damages received or sustained by any person, or persons, by or from said Contractor, his servants or agents, in the construction of said work, or by or in consequence of any negligence in guarding the same, any improper materials used in its construction, or by or on account of any act or omission of the said Contractor or his agents.

PROTECTION AGAINST LIENS

The Contractor further agrees that so much of the money due to him under and by virtue of this agreement as shall be considered necessary by the Engineer may be retained by the County Court until all suits or claims for material and labor furnished said Contractor for prosecution of work provided for in this contract shall have been settled, and evidence to that effect furnished to the satisfaction of the Engineer.

EIGHT-HOUR DAY

Said Contractor further agrees, in the performance of the work under this contract, that no person shall be employed for more than eight hours in any one day or forty-eight hours in any one week, unless in cases of emergency when no other competent laborer is available, and in such cases such labor shall be paid double wages for all overtime.

DIFFERENT CONTRACTORS

Where there are different Contractors employed on the work, each shall be responsible to the other for all damage to work or person or property, or for loss caused by neglect or by failure to finish work at the proper time, thus preventing each portion of the work being finished by the several Contractors at the date named herein for completion or from any other cause.

In witness whereof, said.....County, Oregon, by its County Court, executes this contract, and the said..... do..... sign and seal the same the day and year in this contract first above mentioned.

.....County, Oregon, County Court

By.....

County Judge.

.....

County Commissioner.

.....

County Commissioner.

Attest:.....

County Clerk.

Party of the First Part.

.....

.....

.....

.....

.....

Party of the Second Part.

In the presence of

.....

BOND TO ACCOMPANY CONTRACT

Know all men by these presents that we.....
.....
as Principal, and.....
as Surety, are jointly and severally held and bound unto the County of....., Oregon, in the sum of ..... Dollars ($.....), for the payment of which we jointly and severally bind ourselves, our heirs, executors, administrators and assigns, and successors and assigns, firmly by these presents.

The condition of this Bond is such that, whereas, on the.....day of.....A. D., 191....., the said.....
principal herein, made and entered into a certain contract, copy of which is hereto annexed, with the County of ....., Oregon, and which contract, together with the plans, specifications, general stipulations and proposal, is hereby made a part hereof, by the terms, conditions and provisions of which the said.....
Principal herein,.....to furnish all material and do certain work, to wit: That.....
will construct.....
in.....County, as per Plans, Specifications, General Stipulations, and Proposal, which are made a part of said contract.

Now, therefore, if the principal herein shall faithfully and truly observe and comply with the terms, conditions and provisions of the said contract, in all respects, and shall well and truly and fully do and perform all matters and things by.....undertaken to be performed under said contract, upon the terms proposed therein, and within the time prescribed therein, and shall indemnify and save harmless the County of....., the Engineer, their officers and agents, as therein stipulated, against any direct or indirect damages that shall be suffered or claimed, or injuries to persons or property during the construction of said work and until the same is accepted, and shall pay all laborers, mechanics, sub-contractors and material men, and all persons who shall supply such laborers, mechanics or sub-contractors with materials, supplies or provisions for carrying on such work, and all just debts, dues and demands incurred in the performance of such work, and shall in all respects faithfully perform said contract according to law, then this obligation is to be void, otherwise to remain in full force and effect.

The sureties on this bond hereby consent without notice:

To any change in the Plans, Specifications or Contract when such change does not involve an increase of more than twenty per cent of the total contract price and above that shall be released only as to such excess increase.

For any changes in plans and specifications involving a value greater than twenty per cent of the contract price, the surety shall be held as to such excess increase only upon due notification to him and acceptance by him of these modifications in the contract.

Witness our hands this.....day of....., 191.....

.....

.....

.....

.....

Principal.

.....

.....

.....

Surety.

GENERAL STIPULATIONS

It is further expressly agreed between the parties to the contract that the contract is made subject to the following conditions and stipulations:

BIDDERS TO EXAMINE

It is understood that intending bidders have examined on the ground the work covered by these plans and specifications and have satisfied themselves as to the nature and intent of the work to be done. It is also understood that the contract and specifications will be strictly enforced in order to obtain a neat, finished and workmanlike job.

FUNCTIONS OF ENGINEER

It is mutually agreed between the parties to the contract, that to prevent all disputes and misunderstandings between them in relation to any of the stipulations contained in these specifications, or their performance by either of said parties, that the Engineer shall be an umpire to decide all matters arising or growing out of said contract between them.

The Engineer shall determine the amount or quantity of the work which is to be paid for under this contract, and decide all questions which may arise relative to the fulfillment of these specifications, and his estimates and decisions shall be final and conclusive.

IMPLIED WORK

Any work or material that may have been accidentally omitted in the description of the work, but which is clearly implied shall be furnished by the Contractor the same as if it had been specifically stated.

DISCREPANCY IN PLANS

Work shown on the plans and not mentioned in the specifications, and **vice versa,** will be done as if shown by both, when and where required.

TERMS

Wherever the word "Engineer" is used, it refers to the ....., or his authorized assistant, by whom all explanations and directions necessary for the satisfactory prosecution and completion of the work described in these specifications will be given.

Wherever the word "Contractor" is used, it refers to and means the party or parties who shall have duly entered into contract with the County to perform the work, their duly authorized agents or legal representatives.

Wherever in these specifications, contract, bond, etc., the term "County" is employed, it is understood to mean the County of....., Oregon.

WRITTEN NOTICE

Any written notice to the Contractor which may be requisite under these specifications may be served on said Contractor either personally or by mail, or by leaving the same at his last known place of residence.

DEVIATION FROM SPECIFICATIONS

No deviation from the specifications or detailed plans will be allowed, unless a written permission shall have been previously obtained from the Engineer.

BASIS FOR PAYMENTS

Payments shall be made on estimates of the Engineer in charge of the work.

Payments for the portion of the structure completed and for materials on the ground which are to be finally incorporated in the structure will be based on the proposal attached to the contract which includes the provisions for additions to and deductions from the amounts of certain classes of work as therein set forth, and shall embrace also payments falling under the heads of "Alterations in Details" and "Unclassified Work," as provided for in the paragraphs below.

In case the nature of the work and the amount of the contract render it advisable, a schedule of payments shall follow after these general stipulations to serve as a guide in lump-sum contracts in determining the apportionment of sums due under the proposal as above. This schedule shall be prefaced as follows:

"The Contractor agrees to take partial payments according to the following schedule of quantities and unit prices for the work covered in the original lump-sum contract. This schedule is for convenience only and is not conclusive either as to the amounts or unit values of work actually involved. It may be revised by mutual agreement between the Engineer and the Contractor during the progress of the work if errors affecting the essential justness of payments be found, but any rebalancing of quantities and prices shall not affect the total lump-sum price bid."

In the absence of such schedule, the Engineer shall apportion his estimates to agree with the general terms of the proposal in such a manner as he shall deem equitable and fit.

ALTERATIONS IN DETAILS

The Engineer, during the progress of the work, in order to carry out and complete more fully and perfectly the construction therein agreed to be done and performed, may, by giving written notice to the Contractor, alter any of the Details of Construction in any manner that may be found suitable and expedient, provided the substance of the contract and the contract price be not materially affected. Such

alterations shall not invalidate the contract so far as it is applicable and the Contractor must accept and execute the same as if they were a part of the original contract. At the completion of the work an allowance will be made for such alterations either for or against the Contractor as the case may be, and the value of such alterations will be estimated by the Engineer from the proposal attached to the contract or as unclassified work; or should neither apply, the equitable amount will be estimated by him.

UNCLASSIFIED WORK

Changes, except as provided in the proposal attached to and made a part of the contract or those due to alterations in details of construction, to which neither the proposal is applicable, nor the cost of which must be equitably estimated by the Engineer, shall be considered as unclassified work.

The Contractor shall do such unclassified work and furnish such materials as may be required by the Engineer for the proper completion or construction of the whole work herein contemplated; and he shall make no claim for unclassified work unless it shall have been done in obedience to a written order from the Engineer. All bills for unclassified work done in any month shall be filed in writing with the Engineer before the fifteenth of the following month; and failing to file such claims within the time required, all rights for pay for such unclassified work shall be forfeited. The Contractor shall receive for such unclassified work the actual cost of all materials furnished by him as shown by his paid vouchers plus five per cent.

For such labor and teams as are necessary he shall receive the current prices in the locality, which shall have been previously agreed to in writing by the Engineer and by the Contractor, plus ten per cent for superintendence, use of plant, tools, and appliances, and profit. No indirect expense of any kind shall be included in the cost of materials and applied labor. Said ten per cent for profit will be allowed on any reasonable sum paid by the Contractor for Liability Insurance, which said sum shall have been previously agreed to in writing by the Engineer and Contractor, the same as for labor and team charges on unclassified work.

ESTIMATES OF QUANTITIES

The estimates of quantities made by the Engineer will be furnished the Contractor on request when available, but these are furnished only as a check on his own figures and are not guaranteed. It is expressly stipulated that estimates of quantities are furnished without liability on the part of the County.

DEFECTIVE WORK

The Contractor will be held responsible for the faithful execution of the work in accordance with the specifications. Any defective work that may be discovered by the Engineer or his appointees before the final acceptance, or before final payment shall have been made shall be removed and replaced by work and materials which shall conform to the spirit of the specifications; and the fact that the inspector or other person in charge may have overlooked such defective work shall not constitute an acceptance of the same.

CONTRACTOR'S CAPACITY

The successful bidder shall satisfy the Engineer before the contract is awarded to him that he has or will promptly provide suitable and proper men and tools and machinery for each of the different kinds of work.

WORKMANSHIP

All material and workmanship shall be of the best of its kind or class. All material which may be rejected shall at once be removed from the vicinity and replaced by material of approved quality.

PERSONAL ATTENTION

The Contractor shall give his personal attention to the faithful prosecution of the work.

SUB-CONTRACTS

The Contractor shall not sub-let the work or any part thereof without the written consent of the Engineer, for each individual sub-contract, and the terms of said prospective sub-contract shall be submitted at the same time the request is made.

Sub-contractors or agents of any kind of the Contractor are agreed to be employes of the Contractor and will be subject to the Engineer's direction and control within the limits of the specifications in the same manner and degree as the principal Contractor himself. No sub-contract or transfer of contract shall in any circumstance relieve the Contractor of his liabilities under this contract.

ASSIGNMENT OF CONTRACT

He shall not assign by Power of Attorney, or otherwise, any of the moneys payable under these specifications.

PATENTED DEVICES

The County assumes the responsibility of defending any and all suits brought for the infringement of any alleged patent right claimed to be infringed by the construction herein provided for under plans furnished by said County

and to pay any royalty which said patentee is entitled to under judgment of the court, if any, and to hold such Contractor harmless on account of all such suits or claims for royalty.

Any plans filed by Contractors contemplating the use of any patents or patented devices shall be accompanied by a statement of the exact terms under which such patents or patented devices are used. The Contractor must assume all responsibility for royalties or judgments secured for the use or infringement of any such patent rights and shall hold the County harmless from any suits, royalties or damages on account of the use of any such plans. He shall similarly protect the County against suits for infringements on account of all other patented devices which he may use for purposes of erection and handling men and materials.

CONTRACTOR'S REPRESENTATIVE

Whenever the Contractor is not present on the work, orders will be given to the superintendent or overseer, who may have immediate charge thereof, and shall by him be received and obeyed.

EMPLOYES

If any person employed on the work shall appear to be incompetent, disorderly or unfaithful, he shall, upon the request of the Engineer, be at once discharged and not again employed upon any part of the work.

SUSPENSION OF WORK

The Engineer may suspend operations on any or all portions of the work for such periods as he may deem necessary. The Contractor shall not make any claim or demand for damage by reason of such suspensions in the work, but the period of such suspensions will be excluded in computing the time limit for the completion of the work.

COMPENSATION ACT

The Contractor shall elect to take advantage of and at his own expense, abide by the provisions of Chapter 112, Laws of 1913, as amended by Chapter 271, Laws of 1915, known as the Workmen's Compensation Act.

GUARDS AND LIGHTS

The Contractor shall place and maintain at his own expense sufficient light and proper guards for the prevention of accidents and suitable and sufficient lights at night.

LICENSES AND PERMITS

The Contractor shall procure at his own expense all necessary licenses and permits and shall give adequate notice to owners of all properties which may be affected by his operations.

INTERFERENCE WITH TRAFFIC

Traffic on the railways, highways or water shall not be interfered with without the consent of the proper authorities.

MARKS AND STAKES

All Engineer's marks, monuments or stakes shall be carefully preserved without disturbance until permission for their removal shall be given by the Engineer. All expense incurred through the resetting of stakes that have been destroyed by the Contractor will be charged to the Contractor and deducted from his estimates.

STANDARD SPECIFICATIONS

OREGON STATE HIGHWAY COMMISSION

To be applied to this contract

SCOPE OF STANDARD SPECIFICATIONS

The following specifications are general and drawn up in accordance with the standards in use in the Bridge Department of the State Highway Commission. Clauses, treating of other material or classes of work than those shown on the drawings or called for under special clauses indicating the scope of this contract, will be considered as non-existent and be ignored.

It should be noted in connection with these specifications, unless accompanied by "Specifications for Loadings, Stresses, Calculation and Design," that they are based on the assumption that plans have already been provided or approved by the Bridge Department of the State Highway Commission, incorporating all the necessary details of loadings and design.

LUMBER

All lumber used under this contract, unless otherwise noted, shall be No. 1 common Douglas fir, thoroughly sound, free from wanes, shakes, large black or unsound knots, or knots in clusters. It shall be sawed square and true to the sizes shown and such pieces as have defects which affect their strength shall be excluded. All lumber shall conform to the standard sizing and grading adopted by the West Coast Lumber Manufacturers' Association.

FOUNDATIONS

All foundations, cribs, footings, caissons, and tubes are to be sunk and excavated to the depths shown on plans, or to such depths as the Engineer may deem necessary as the work progresses. In no case shall foundation concrete if carried on piles or built on hardpan or other suitable material (rock alone excepted), in or adjacent to the stream, be carried to a depth less than four feet below the river bed at its lowest point contiguous to said foundation without express authorization in writing of the Engineer.

Before any concrete is poured in footings of piers or abutments, the Engineer shall approve the depth of excavation and character of foundations.

ROCK FOUNDATION

Where rock foundations for piers are secured the material overlying the rock shall be removed, after which the latter shall be leveled or stepped off as the Engineer may direct and then cleared of all loose material before footings are placed.

Anchor rods not less than two inches in diameter and six feet long shall be set as shown on accompanying plans.

FOUNDATION CHANGES

If the physical conditions encountered justify any changes in the quantities shown on the plans, the Engineer shall determine such quantities and payment shall be rendered the Contractor as provided in the proposal or under classified work.

COFFERDAMS

All foundations, unless otherwise specified, are to be constructed by open excavation which shall be shored, braced or protected with cofferdams in accordance with approved methods.

Where cofferdams are used, the Contractor shall, on request, submit working drawings showing his method of cofferdam construction and forms for piers, where plans are not otherwise provided him.

Type of cofferdam and clearance for pier bases will be subject to the approval of the Engineer but strength and other details of design are left to the Contractor who will then be responsible for their successful use and safety. Especial attention is here directed to the necessity for sufficient clearance for working freely inside the cofferdam and for providing against sudden rises in the level of the stream.

No direct payment will be made for cofferdam materials or the removal of same, as the cost thereof must be covered by the prices for the excavation and for the concrete in place.

OBSTACLES

Bidders must allow in their estimates for the chance that they may encounter boulders, logs, piling, or other obstacles in the river bottom at the site of the piers and other foundations.

There shall be no extra pay allowed because of difficulty found in driving through, sinking or removing the above obstacles.

CONCRETE IN PIER FOUNDATIONS

When the excavations are at the depth required, the water shall be pumped out and concrete foundation work below the water line, so far as possible, be done in the dry. If, in the opinion of the Engineer, it be necessary, a small amount of concrete sufficient to form a sealing course may be deposited in water by the use of a bottom dumping bucket or an approved tremie.

When starting to deposit concrete through a tremie, the outlet shall be kept closed until it touches bottom, the tremie being filled sufficiently with concrete to prevent water from entering into the existing head; thereafter the tremie shall be kept so filled and the outlet so buried in the concrete along

the bottom as to prevent undue separation of the cement from the aggregate by water action. Adequate apparatus shall be provided to permit the uniform deposition of the concrete in layers by free movement over the area of the cofferdam and by control of the outlet of the tremie at the desired depth below the surface of the concrete being poured.

After such concrete has set, the water shall, wherever possible, be pumped out and the remaining concrete deposited in the dry.

Pumping from the inside of foundation forms will not be permitted while the concrete is being placed.

CONCRETE UNDER WATER

It is expressly understood that no concrete shall be deposited in water except with the written permission of the Engineer and the existence of conditions necessitating such handling of concrete shall be determined solely by him.

In all cases when concrete is placed under water a "Class A" mixture shall be used. Under no condition will it be permitted to deposit concrete in flowing water.

REMOVAL OF TIMBER, CRIBBING AND FORMS

All timber above the level of the ground or above extreme low water is to be removed by the Contractor from around the piers and other foundations before the work will be considered completed.

Foundations on piling shall preferably be enclosed by permanent water-tight sheet piling with tops sawed off at the level of extreme low water. For such foundations the Contractor shall include in his proposal all charges for leaving his sheeting in place and for cutting off as specified.

PILES

Material—All piles shall be first quality Douglas fir, sound and free from defects. They shall have a fairly uniform taper.

Sweep—They shall not have more than one inch sweep for each twenty feet of length of pile.

Size—For lengths twenty-five feet and under, the diameter shall vary uniformly from a minimum of nine inches at the point to thirteen inches at cutoff.

For lengths of from twenty-five to fifty feet, the diameter shall vary uniformly from a minimum of eight inches at the point to fourteen inches at cutoff.

For all lengths over fifty feet the diameter shall vary uniformly from a minimum of seven inches at the point to fifteen inches at cutoff.

The minimum diameters given shall read strong in all cases and the maximum diameter at butt shall not exceed one and one-third the minimum at that point.

In cutting the piles, allowances must be made for butts sufficiently large to give the required diameter when cut off.

Location—Piles shall be located accurately in positions indicated, and cut off squarely.

Driving—They shall be handled and driven in a manner that will secure them against injury and in case of unit prices called for it shall always mean the length under cut-off plus three feet per pile for waste.

Shoes—If the material encountered warrants, piles shall be shod with metal shoes, to be supplied under the clause for extra material.

Refusal (Pier Foundations)—All piles for piers shall be driven to practical refusal which is here understood to be such as would meet the condition of the Engineering News formula for a loading of twenty tons per pile or such other test of approximately the same rigidity as the Engineer shall direct. If in the Engineer's opinion the nature of the foundation makes it advisable, these piles shall be driven under a double jet.

Under no interpretation of this clause covering penetration shall the requirements be considered as fulfilled when in the opinion of the Engineer the pile rests on logs at a distance into the material of the bottom insufficient either to give the necessary frictional resistance without bearing or to furnish adequate lateral support.

No pile for these foundations shall have a penetration of less than twelve feet in firm ground, unless otherwise authorized by the Engineer after conditions are fully known. In this case the Engineer shall determine the necessity for and order driven any piles additional to those drawn on the plans and shall locate any brace or batter piles required for lateral support.

Refusal (Wood Bents for Approaches)—Piles for wood bents shall be driven to such refusal under the Engineering News formula as will in the opinion of the Engineer conform to a safe loading per pile upon the foundation material encountered.

For the purpose of determining such compensation for waste material as is allowed under the terms of the proposal for changes in length of piling, the Engineer shall estimate and deduct reasonable salvage on such material as is unusable on any part of the work remaining to be done.

Cut Off—All wood piles shall be cut off at or below the water line unless otherwise shown or specified.

STEEL BRIDGES

PLANS

DETAILED PLANS

Plans showing the general details will be furnished the Contractor, drawn up in accordance with standard specifications covering loadings and details of design. It is not the purpose, however, to prevent any bidder from detailing the connections in accordance with the bidder's shop-practice, provided the strength and appearance of the structure are not impaired. The Contractor shall make such detailed shop plans as are necessary for the proper performance of the work in the shop and field and he shall submit them to the Engineer for approval before beginning shop work.

Payment for working drawings shall be included in the prices named for materials in the contract.

SIZE

All plans prepared by the Contractor shall measure twenty-three inches between upper and lower border lines. They shall preferably measure thirty-four inches between the side border lines, this dimension being considered as a minimum. A margin one-half inch wide shall be provided outside of the border line on all sides of each sheet, except the left-hand side, where a margin of one and one-half inches shall be provided for binding. A title shall be placed in the lower right hand corner of each sheet similar to the one on the general standard plans. The execution of these plans shall be neat, distinct and workmanlike.

NUMBER OF SHOP DRAWINGS

The Contractor shall furnish without additional charge two sets of cloth blue prints of all erection diagrams used on his work and such additional sets of paper blue prints of working drawings as the Engineer or County may find necessary.

CHANGES IN SHOP DRAWINGS

After approval of the shop plans by the Engineer, no changes whatever will be made on them without his written consent.

While for minor revisions of completed and approved working drawings no extra payment will be made, whenever in the Engineer's opinion the Contractor is entitled to extra compensation for material changes in them, the Engineer will fix the amount of such compensation and the Contractor accept it as payment in full.

INTERPRETATION

The decision of the Engineer shall control in the interpretation of plans and specifications during the execution of the work hereunder.

MATERIAL

Unless otherwise designated on the plans, all material shall conform to the standard specifications for structural steel for bridges as revised and adopted by the American Society for Testing Materials, Serial Designation A7-15 and similarly to their latest standards for cast iron and cast steel.

STEEL

Process—The steel shall be made by the open-hearth process.

Quality—All steel shall be of uniform quality for each class. It shall be straight, without buckles or kinks, and free from injurious seams, flaws, laminations, and other defects.

Variation in Size—The variation in cross section or weight of rolled material of more than 2½ per cent from that specified shall be cause for rejection, except that for wide sheared plates an allowance will be made in accordance with the latest specifications of the American Society for Testing Materials.

Fracture—The entire fracture of test pieces shall be silky.

Rivet Steel—Rivet rods shall withstand cold bending without fracture through 180 degrees so that the parts on each side of the bend come into actual contact throughout their length. When nicked and bent around a bar of their own diameter, they shall break gradually and give a fine, uniform, silky fracture.

CAST IRON

Castings—Except where chilled iron is specified, all castings shall be of tough gray iron, free from cracks, cinder pockets, blow holes, and other injurious defects, and shall not contain more than 0.10 per cent of sulphur. All castings will be true to pattern and of workmanlike finish.

Test Bars—Test bars one and one-quarter inches in diameter, 15 inches long, loaded in the middle between supports 12 inches apart, shall be capable of supporting a load of at least 2,900 pounds and shall deflect at least 0.10 of an inch before rupture.

CAST STEEL

Quality—Steel castings shall be made of medium steel. They shall be free from large or numerous blow holes, tough and uniform in quality, permitting of chipping and forging without cracking. All steel castings shall be annealed. They shall be true to pattern and of workmanlike finish.

Test—At least two pieces of every melt shall have a coupon twelve inches long and two inches square attached for testing. Specimens prepared from these coupons shall have an ultimate tensile strength of between 65,000 and 75,000 pounds

per square inch. They shall develop an elongation of fifteen per cent in two inches, including the fracture. The fracture shall be bright and clean and free from blow holes.

WELDING AND PATCHING

No welding or patching shall be done without the consent of the Engineer.

SHOP WORK

WORKMANSHIP

All workmanship shall be first-class in every particular.

STRAIGHTENING

All material must be carefully straightened before being laid out.

LAYING OUT

All laying out and punching shall be done so accurately that when pieces are assembled the holes will be truly opposite.

DRIFTING

Drift pins shall only be used in bringing together the several parts forming a built member and must not be driven with such force as to upset or destroy the metal about the hole.

SHEARING

Shearing shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

PUNCHING

In punched work the internal diameter of the die used in punching shall not exceed the nominal diameter of the rivet by more than one-sixteenth of an inch.

In reamed work the internal diameter of the die used in punching shall be at least three-sixteenths inch less than the finished hole.

No punching will be allowed in material thicker than seven-eighths inch.

REAMING

In reamed work the rivet hole shall be reamed to a diameter one-sixteenth of an inch larger than the nominal diameter of the rivet.

ASSEMBLING

All burrs and inequalities shall be removed before assembling the pieces of any riveted member, so that the surfaces may come in close contact.

Riveted members shall have all parts well pinned up and firmly drawn together before riveting is commenced.

DEFECTIVE RIVETS

Gauging, caulking or recupping will not be permitted on any part of the work. All loose, burned or otherwise defective rivets shall be removed and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal.

PLANED ENDS

Sheared edges or ends, where required, shall be planed at least one-eighth of an inch.

FLANGE PLATES

Wherever several flange plates of equal width are superposed they shall be flush on edge when riveted up.

STIFFENERS

All stiffeners must have a driving fit.

BUILT MEMBERS

Built members when finished must be straight and true and free from twists, kinks, buckles, and open joints between component pieces.

ABUTTING JOINTS

Abutting joints shall be dressed true and straight, and fitted close together. In compression members depending on contact bearing, abutting ends shall be planed true to the angle of the joint so that they shall have even bearings after they have been riveted up complete and perfectly aligned.

RIVET DRIVING

Rivets must be driven by direct acting power riveters whenever possible; they shall completely fill the holes, have full heads concentric with the holes and in close contact with the surface; heads of rivets of same diameter must be uniform. Counter-sinking must be neatly done; counter-sunk rivets must completely fill the holes. Chipping of countersunk rivets is to be avoided as much as possible.

CHIPPING

All chipping shall be done in a neat and workmanlike manner without breaking out of metal.

BOLTS

When turned bolts are specified the holes must be reamed to a uniform diameter and the bolts turned to a driving fit.

EYE-BARS

Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The forms of heads will be determined by the dies in use at the works where the eye-bars are

made, if satisfactory to the Engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than one-sixteenth inch from that specified.

PIN-HOLES

Eye-Bars.—Before boring, each eye-bar shall be properly annealed and carefully str ightened. Pin-holes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins one-thirty-second inch smaller in diameter than the pin-holes can be passed through the holes at both ends of the bars at the same time without forcing.

Built Members.—Pin-holes shall be bored true to gauges, smooth and straight, at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up.

Center Distance.—The distance center to center of pin-holes shall be correct within one-thirty-second inch, and the diameter of the holes not more than one-fiftieth inch larger than that of the pin, for pins up to six inches diameter, and one-thirty-second inch for larger pins.

TURNED MEMBERS

All pins, rollers, turntable wheels, etc., shall be accurately turned to a gauge and shall be perfectly smooth. To obtain this result the inspector may require that a water cut be taken.

BENDING

All bends in steel must be made cold wherever possible. Whether such bends are made cold or by heating, the entire piece must be subsequently annealed.

CONNECTION ANGLES

Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder.

MILLED ENDS

In case milling is needed or required after riveting, the removal of more than one-sixteenth of an inch from the thickness will be cause for rejection.

RIVET DIAMETERS

Unless otherwise noted, all rivets shall be three-quarters inch in diameter.

RIVET PITCH

The maximum pitch in the line of stress shall not exceed six inches or sixteen times the thickness of the thinnest outside plates.

The minimum pitch shall not be less than two and one-quarter inches for three-quarter inch rivets and two inches for five-eighth inch rivets.

DISTANCE FROM EDGE

The minimum distance from the edge of any piece to the center of rivet hole must not be less than one and one-fourth inches for three-quarter inch rivets and one inch for five-eighth inch rivets. The maximum distance from any edge to the center of rivet holes shall not exceed eight times the thickness of the thinnest outside plate, or six inches.

SCREW THREADS

Screw threads shall make tight fits in the nuts and shall be United States standard, except above the diameter of one and three-eighths inches, when they shall be made with six threads per inch.

UPSETTING

The ends of all rods shall be made by upsetting or forging into shape. No welds will be allowed except to form the loops of laterals, counters or sway rods.

INSPECTION AND TESTS

IMPERFECT WORK

It is expressly understood that the inspection will not relieve the Contractor of the responsibility for imperfect work or material of any nature.

FACILITIES FOR INSPECTION

All facilities for inspection of material and workmanship shall be furnished by the Contractor. He shall furnish without charge the use of testing machine of sufficient capacity and the services of an operator at all mills and foundries where material under these specifications is being manufactured; or he shall arrange for testing at some other place satisfactory to the inspector.

NOTICE TO INSPECTOR

Timely notice shall be given to the inspector when work is to be commenced on any part, enabling him to be present for inspection. The inspector shall have access to all establishments where work for the purchaser is in progress.

DEFECTIVE MATERIAL

The acceptance of any material or finished members by the inspector shall not prevent subsequent rejection of the same if found defective after delivery, and the Contractor shall replace the rejected material without extra compensation.

EYE-BAR TESTS

Full-sized tests of eye-bars may be ordered by the Engineer. Eye-bars tested to destruction shall break in the body and shall develop an ultimate strength of not less than 57,000 pounds per square inch and an elongation in twenty feet of not less than twelve per cent. The material used for the successful tests will be paid for at the contract price, less scrap value.

PAINTING

CLEANING AND SCRAPING

All metal work, before leaving the shop, shall be thoroughly cleaned from all loose scale, rust and dirt by the most effective known methods, such as wire brushes and scrapers.

SHOP PAINTING

It shall then be given a coat either of the best carbon primer or of red lead in oil in the proportion of thirty pounds of prepared paste to one gallon of pure linseed oil, or other suitable paint of approximately the same cost, as directed by the Engineer.

The coat shall be thoroughly dried before the metal is loaded for shipment.

All surfaces coming in contact shall be well painted before being riveted together. Bed plates, bearing plates and any other parts which are not accessible for painting after erection, shall have three coats of paint; one at the shop and the other two in the field, before erection. The pins, rollers and pin-holes shall be coated with white lead and tallow before shipment.

FIELD PAINTING

After the structure is erected, the metal work shall be thoroughly cleaned from mud, grease or any other objectionable material that may be found upon it. All rivet heads and other places where the paint has been damaged shall be repainted. Then the entire surface shall be thoroughly and evenly painted with two coats of the paint designated.

COLORS

All three coats of paint are to be of different color.

THINNING OF PAINT

No thinning of paint will be permitted without the written permission of the Engineer.

WEATHER CONDITIONS

No painting will be done in wet or freezing weather unless under cover where temperature is above the freezing point.

MATERIAL AND WORKMANSHIP

The quality of all paint whether carbon, graphite or lead in oil shall be of the first grade and subject to the approval of the Engineer. No coat shall be applied until the preceding one is thoroughly dry.

The aim of this specification is to guarantee that good materials shall be applied, in a workmanlike manner to the steel, and that a good body is insured to each coat. The idea in calling for different colors is to reveal the weight of that body and to visually demonstrate that each coat is fully applied to the entire surface, thereby facilitating inspection.

At the discretion of the Engineer, paint of any adopted grade and type shall be delivered at the shop and to the field in sealed packages to be opened and applied under his supervision.

RECESSES

All recesses which would retain water or through which water could enter must be filled with thick paint or some water-proof cement before receiving the final coat.

ERECTION OF BRIDGES

(See also "Foundations" and "Concrete in Forms and Steel Reinforcement.")

SCOPE OF WORK

The Contractor shall furnish all necessary material, labor, tools and appliances for building abutments and piers; for erecting, riveting, adjusting and painting all metal work for steel bridges; for laying floors, placing guards and railings; and for the erection of wood approaches or spans, either of combination wood and iron construction or concrete. All falsework shall be supplied and placed by him.

FALSEWORK

For falsework of the spans, working drawings, indicating its strength and adaptability to the work shall be supplied the Engineer on request but his approval of their general plan or acquiescence in work constructed according to them shall not relieve the Contractor of responsibility for successful erection of the steel.

ANCHORS

The Contractor shall drill the necessary anchor bolt holes in the masonry, or, if called for on the plans, provide holes in said masonry at the time it is constructed. He shall place the bolts in position. Whenever plans require it the bolt holes shall be drilled before the bedplates are set on the masonry. The anchor bolts shall be properly set in neat Portland cement grout.

BASES AND SHOES ON MASONRY

Bases, shoes, and all superstructure metal which is to rest on masonry, including hand rails on walls, shall be set to exact position and level and be supported on iron wedges, the space between metal and masonry being filled with a 1 to 2 mortar or grout. The spaces in and above the shoes and all parts of the posts capable of containing water shall be filled with one-two-four concrete, the aggregate passing through a one-inch ring; top surface finished to drain. The cost of this work is included in the price of the steel.

HANDLING

The Contractor shall unload and store the material in a careful, systematic way to prevent injury by rust or otherwise and to prevent loss of minor pieces. No stored material shall be permitted to rest on the ground or in water and without proper skids.

FIELD RIVETS

Field rivets must be tight and must have both heads concentric with the axis of the rivets. The heads of field rivets shall be of uniform size and have the same dimensions as the shop rivets whenever possible.

All field rivets, unless otherwise permitted by the Engineer, shall be driven by pneumatic hammers of a type and size to be approved by him. No loose or imperfect rivets will be allowed to remain in any portion of the metal work. In removing rivets the surrounding metal shall not be injured and, if necessary, the rivets shall be drilled out. All splices and field connections shall be securely bolted before riveting. When not carrying traffic at least thirty per cent of all holes shall have bolts.

SPLICES

All tension splices shall be riveted up complete before blocking is removed. Rivets in compression splices shall not be driven until the members have been subjected to full dead load stresses.

FIELD BOLTS

All field bolts shall be full size and of best quality of material. All turned bolts shall fit the holes with a driving fit.

REAMING AND DRIFTING

Whenever field holes do not come truly opposite each other in such a way as to permit the insertion of rivets, such holes shall be enlarged by reaming and larger diameter rivets shall be used, if required by the Engineer. Neither forcible drifting nor gauging will be permitted. Light drifting will be permitted only for the purpose of drawing the parts together.

PINS

Threads of pins shall be protected by pilot and driving nuts while being driven into place. Nuts on pins and on bolts remaining in the structure shall be effectively locked by checking the threads.

CLEARING THE SITE

After completing the work of erection the Contractor shall remove all old material and debris resulting from his operations and place the premises in a neat condition.

REMOVAL OF OLD BRIDGE

When a new bridge is not located sufficiently far from an old bridge to enable its construction to proceed without interfering with the traffic on the old bridge, the Contractor will be required to remove and alter only such portions of the old bridge as may interfere with his operations, or, if the contract shall include the removal of the old work, the portions in the water shall be removed to the bed of the stream, and that on land well below the surface, unless provided for otherwise.

All material in the old structure of value which the County may wish to save shall be piled up on skids along the roadway as directed.

NAME PLATE

A brass name plate of neat design and finish, giving the names of the officials of the purchaser, the Engineers, and the Contractors, shall be firmly attached to each end of the bridge. All name plates shall be subject to the approval of the Engineer.

CAMBER

Truss spans shall be cambered. The Contractor shall prepare camber diagrams along with the shop details which shall be subject to the Engineer's approval.

ALIGNMENT AND GRADES

The general location and elevation of the structure shall be as indicated on the plans. All parts of both the sub-structure and the super-structure must be in exact alignment and the Contractor shall provide all frames, falsework, shoring, forms, anchors, guides and temporary structures necessary to this end. His contract price is to cover all work and materials involved.

Bench marks and other necessary points at intervals shall be furnished him but he shall determine from these points at his own expense the alignment, elevation and position for all intermediate construction subject to check and correction of the Engineer.

SPLICES AND PACKING BLOCKS IN WOODEN TRUSSES

Particular attention shall be given during adjustment of wooden splices and packing blocks to see that undue initial stresses are not introduced either in the packing blocks and splices or in the members which they connect, so that during the removal of blocking from falsework the dead load stress will be distributed evenly among all members designed to meet it without incurring the risk or failure in the splices and blocks or the members which they connect.

CONCRETE IN FORMS AND STEEL REINFORCEMENT

CLASSIFICATIONS

(Screened and Graded Aggregate)

CLASS "A"

Class "A" concrete shall consist of one cubic foot, ninety-four (94) pounds, of Portland cement, two cubic feet of fine aggregate, four cubic feet of coarse aggregate, the several ingredients being measured separately before mixing.

CLASS "B"

Class "B" concrete shall consist of one cubic foot, ninety-four (94) pounds of Portland cement, two and a half (2½) cubic feet of fine aggregate, and five (5) cubic feet of coarse aggregate, the several ingredients being measured separately before mixing.

CLASS "C"

Class "C" concrete shall consist of one cubic foot, ninety-four (94) pounds, of Portland cement, three (3) cubic feet of fine aggregate, and six (6) cubic feet of coarse aggregate.

QUANTITIES FOR ONE YARD OF CONCRETE

Kind	Barrels Cement	Sand Cubic Yards	Broken Stone or Screened Pebbles Cubic Yards
Class "A"	1.50	0.42	0.84
Class "B"	1.25	0.44	0.87
Class "C"	1.00	0.44	0.89

VARIATION IN PROPORTIONS

The proportions of sand and gravel called for in the above classifications are approximate only and may be varied slightly when desired by the Engineer to obtain the densest mixture possible for the particular class required.

The table is based on forty per cent voids in the coarse aggregate, which would ordinarily be given by the screening required under the heading of "Aggregate" below. Cement is assumed to weigh 376 pounds per barrel, or 94 pounds per sack.

AGGREGATE

FINE AGGREGATE

The fine aggregate shall consist of dry, clean, sharp quartz grains, and shall not contain more than five per cent, by weight, of clay and loam, or other foreign materials.

The grains shall be well graded and of such size that all will pass a ¼-inch mesh screen; not less than 50% a No. 8 screen; not more than 20% a No. 50 screen, and not more than 6% a No. 100 screen.

COARSE AGGREGATE

The coarse aggregate may consist of either broken stone or gravel. Stone shall be sound, clean, hard and tough and free from dust and dirt, and range in size from one-quarter inch up to one and one-half inch for Class "A" concrete, and from one-quarter inch to two and one-half inch for other classes of concrete.

UNSCREENED OR PIT RUN GRAVEL

If the Engineer permits the use of unscreened or pit run gravel, the amount of sand passing a one-quarter inch screen shall be frequently determined and the concrete shall be proportioned by the following tables for the various classes of concrete as specified:

The sand and stone of pit run gravel shall be equal to that of the above specification for fine and coarse aggregates.

CONCRETE—PIT RUN GRAVEL

Sand Passing One-Quarter Inch Screen Percentage of Pit Run Gravel	Proportions		Number of Barrels Cement Per Cubic Yard of Concrete If Pit Run Gravel Only Is Used
	Cement Sack	Pit Run Gravel Cubic Feet	
Class "A"—			
42 per cent	1	4.5	1.50
45 per cent	1	4.0	1.68
55 per cent	1	3.5	1.90
65 per cent	1	3.0	2.25
75 per cent	1	2.5	2.70
85 per cent	1	2.25	3.00
95 per cent	1	2.0	3.40
Class "B"—			
42 per cent	1	5.5	1.22
45 per cent	1	5.0	1.35
55 per cent	1	4.5	1.50
65 per cent	1	4.0	1.68
75 per cent	1	3.5	1.92
85 per cent	1	3.0	2.25
95 per cent	1	2.5	2.70
Class "C"—			
42 per cent	1	7.0	0.97
45 per cent	1	6.5	1.03
55 per cent	1	5.0	1.35
65 per cent	1	4.5	1.55
75 per cent	1	4.0	1.68
85 per cent	1	3.5	1.92
95 per cent	1	3.0	2.25

Note.—The above tables are based on the assumption that the pit run gravel is used as found and that the minimum proportion of sand in it passing a one-quarter inch screen is 42 per cent. If the percentage of sand is less than

this, the deficiency must be made up with sand obtained by screening pit run gravel, with sand from outside sources, or by screening and eliminating the necessary amount of stone. If the percentage exceeds 42 per cent, sand may, if desired, be removed by screening, or gravel be added from supplies obtained either from the pit run by screening, or from outside sources so that any economical percentage from that of the natural state down to 42 per cent may be used; provided, that for any case the proportion of cement to sand passing a one-quarter inch screen shall be approximately that of one sack (94 pounds) to two cubic feet for Class "A" concrete, one sack to two and one-half cubic feet for Class "B" concrete, and one sack to three cubic feet for Class "C" concrete, and the total amount of cement to the yard of concrete be as shown in these tables for pit run gravel.

Quality.—The quality of pit run gravel shall be governed strictly by the specification and no reference to the location of these materials on the plans or statement as to their nature except in the contract documents themselves shall be construed to obviate the necessity of washing, screening and grading them if in the Engineer's opinion it be required.

CEMENT

TESTS

All cement used under this contract shall be of a brand approved by the Engineer, and must conform to the latest standard specifications for Portland cement adopted by the American Society for Testing Materials. Any cement rejected by the Engineer shall be removed at once from the work.

STORAGE

To allow of ample time for inspection and test, cement shall be stored in original packages, in a suitable water-tight building with its floor raised above the surface of the ground, in such manner that easy access to and full identification and count of the packages in each individual shipment may be permitted. This accessibility for purposes of count shall be maintained throughout the period of their use. Every storage facility shall be provided by the vendor or Contractor and **a period of at least twelve (12) days shall be allowed to permit of inspection and necessary tests.** Cement which may have passed the tests required within the period above fixed, may, upon express permission of the Engineer, be released.

REPACKED CEMENT

Repacked cement shall not be submitted for test, and any such cement discovered in a shipment shall be considered sufficient cause for the rejection of the entire shipment.

GUARANTEE OF USE

The total amount of cement used on the work shall be determined by the proportions specified for the different classes of concrete and by the total yardage placed in those classes; any deficiency in the amount used compared with the amount so required shall be made up by the contractor with cement which shall become the property of the county or the value of such cement shall be adjudicated to said county on completion of the work.

WATER

The water to be used shall be clean and free from oil, acid, alkali or other injurious matter.

MIXING

The concrete shall have the proportions specified under the particular class called for on the plans.

For the purpose of securing the proper proportions of cement in the aggregate under specification requirements, in addition to the check on quality obtained at the mixer, the Contractor shall keep records of the daily yardage of different classes of concrete run and the number of sacks or packages of cement used in each class. These records shall be available to the Engineer, who on request, shall at all times have access to and be aided in the identification of both empty sacks or packages and remaining cement stocks for purposes of count. All concrete shall be mixed in a mechanical batch mixer, which must be approved by the Engineer unless special permission is given to mix by hand. Cement shall be measured at the mixer in its original packages as put up by the manufacturer and no style or capacity of mixer shall be used which is not adapted to facilitate proportioning and count in this way. The dry materials in the proportions as specified shall be deposited in the mixer simultaneously. The proper amount of water shall then be added and mixing shall continue until all the ingredients shall have been uniformly distributed, each particle of sand or quartz being thoroughly coated with the cement and each particle of stone with mortar.

CONSISTENCY

The ingredients of the concrete shall be so mixed as to produce a mortar homogeneous in character and uniform in color and texture, of such a consistency that the mortar will flush to the surface under tamping without separation of the cement and the aggregate.

FORMS

PLANS

The forms shall be constructed in accordance with detailed drawings covering the work or where such drawings are not furnished, the Contractor shall at the request of the Engineer, submit information regarding his proposed scheme of work, which shall be satisfactory to the Engineer.

LUMBER

The lumber shall be of sound merchantable stock. Sheeting for forms shall be No. 1 common lumber, surfaced on one side or as approved by the Engineer.

BRACING

All forms shall be constructed so as to be held rigidly in place to line and elevation. If at any point of the work after the concrete has been placed, the forms show signs of bulging or sagging, that portion of the concrete affected shall be immediately removed on notice from the Engineer and the forms shall be properly supported. No extra allowance shall be made to the Contractor for such work.

In the construction of centering for arch spans or support of viaduct girders and slabs, provision shall be made for wedging up the blocking to take up any settlement due to defective support or other cause.

MOULDING

Moulding having three-quarter-inch sides shall be used for all exposed corners.

All grooves, joints, mouldings, pilasters, panels, copings and other details shall be true to line and dimensions.

The construction of the forms shall be such that in striking them, the edges of mouldings and other projecting parts may not be defaced.

EXPANSION AND RELEASE OF FORMS

To prevent the lifting or cracking of concrete, due to expansion in the forms of copings or other projecting parts, particular care shall be exercised in construction of the forms which shall be so built that they may easily be released and allowed to settle after a partial setting of the concrete.

TIGHTNESS OF FORMS

They shall be made thoroughly tight to prevent leakage of mortar, and, before placing concrete against them, shall be thoroughly wetted.

CLEANING OUT FORMS

Before any concrete is placed, all shavings and debris of any nature shall be removed from within the forms.

TIE WIRES

After removal of the lagging, the tie wires shall be clipped beneath the surface and the ends pointed over, to the satisfaction of the Engineer.

CONCRETE RAILS AND COMBINATION RAIL-GIRDER

Forms for concrete railings or girders used also as side railings shall not be finally lined up until the floor concrete has been poured as the settlement due to weight coming on the centering tends to distort the prominent lines of the rail.

DEPOSITING CONCRETE

CARE IN TRANSPORTING

The transportation of concrete from the point of mixing to the point of deposit shall be conducted in such manner that mortar may not be lost and the concrete shall be so handled that when deposited in place it shall be uniform in composition throughout, showing neither excess nor deficiency of mortar in any part of the mass. If the concrete be transported by wagon or cart, every such vehicle shall have a tight body.

TIME LIMIT FOR DEPOSIT

The concrete shall be in place within thirty (30) minutes after discharge from the mixer or the mixing platform.

LENGTH OF HAUL

The length of haul shall not exceed six hundred (600) feet except upon express permission of the Engineer.

SPADING

The concrete shall be deposited evenly in layers and immediately spaded or agitated by suitable tools in such a manner as to produce a thoroughly compact concrete of maximum density. All gravel or broken stone shall be well spaded back from the faces of the forms, so that a smooth mortar surface may be attained.

HEIGHT OF FALL

The dropping of concrete from a height without remixing and spreading the same is expressly forbidden. Concrete in long columns or in deep, narrow walls shall be placed through a tremie, which shall be so manipulated as to prevent separation of the aggregate. The mixture shall be wet enough to move readily in the tremie and be easily spaded with long-handled rammers and spading tools, but only so much water shall be used as the material will accommodate without separation. Excessive care shall be used to prevent the occurrence of streaky concrete and voids.

PLACING OF STEEL

No concrete shall be poured until the reinforcing steel shall have been placed as required in the plans, and firmly secured by wiring or other approved method, to prevent its displacement.

WORKING OVER FRESH CONCRETE

For the pouring of concrete no method of runway construction or other manner of placing will be allowed which permits the jarring of forms carrying new concrete and the method adopted shall be subject to the approval of the Engineer.

JUNCTION OF OLD AND NEW WORK

The surface of old concrete shall be thoroughly cleaned and slushed with neat cement or a Portland cement mortar not leaner than one (1) part of Portland cement to two (2) parts of concrete sand before new concrete is poured.

CONTINUOUS POURING

The Contractor shall so conduct his work that the placing of concrete for any integral part of the structure shall be continuous; and in all cases the placing of concrete shall be stopped only at such points as the Engineer may direct.

EXPANSION AND CONSTRUCTION JOINTS

LOCATION

Expansion and construction joints shall be placed as provided on the detailed plans. If detailed plans have not been provided, such joints shall be placed as directed by the Engineer, and in a manner satisfactory to him.

CONSTRUCTION JOINTS

In case of stoppage of work due to rain or other unavoidable cause, during the pouring of any member or integral part of the structure, a joint, substantially normal to the member, shall be left.

REMOVAL OF FORMS

No forms shall be struck nor wedges removed unless with the express permission of the Engineer.

FINISH OF EXPOSED SURFACES

The following finish shall be given to exterior surfaces where indicated on drawings:

After the forms are removed the concrete must be thoroughly wet with a brush and then rubbed with a coarse No. 16 carborundum stone, bringing the surface to a lather. After this stone has been used sufficiently to take off the rough projections, the lather must be washed off with a brush

and the concrete again wet, and then dusted with a mixture of dry sand and cement, the proportions being one part of cement to two parts of sand. This is then rubbed into the surface with a coarse No. 16 stone. Care must be taken not to allow any of the mortar to remain on the surface. The final finish is to be obtained by rubbing the whole surface thoroughly with a No. 30 carborundum stone. A plaster finish or cement wash shall not be used unless with the express permission of the Engineer.

PROTECTION OF WORK

FREEZING WEATHER

The mixing of concrete during freezing weather shall not be permitted, except upon express permission of the Engineer, and in no case shall frozen material be used in mixing. In case the Engineer permits the laying of concrete in freezing weather ,the sand, water and aggregate shall be heated. The use of salt for prevention of freezing is expressly forbidden. Effective means shall be provided to prevent freezing of concrete in place, before the final set.

CURING AND WETTING DOWN

All finished and unfinished concrete shall be kept thoroughly wetted for not less than twelve (12) days, and in dry weather the entire surface shall be covered and protected from the sun's rays. Any concrete which may have been injured by drying, freezing, or other cause, shall be removed upon order of the Engineer.

STEEL REINFORCEMENT

TYPE AND GRADE

The steel reinforcement shall be of a type indicated on the plans or when not indicated, as may be directed by the Engineer. The grade shall be mild steel.

QUALITY

The standard specifications for Billet Steel reinforcement as adopted by the American Society for Testing Materials, Serial Designation A15-14, shall determine the quality used.

REROLLED STEEL

No re-rolled material of any kind shall be allowed and any attempt to substitute steel manufactured from old steel rails will be considered a violation of the contract and adequate reason for its cancellation.

NOTICE PRIOR TO SHIPMENT

Timely notice shall be given the Engineer so that inspection of this material can be arranged for at the mill or elsewhere before shipment.

DOCUMENTARY EVIDENCE

In lieu of the above inspection other evidence of the quality of material and process of manufacture may be accepted when satisfactory to the Engineer, but this evidence must be presented before shipment.

REJECTION OF MATERIAL

It is expressly understood, however, that acquiescence in shipment based on any other evidence except that of actual test in no way relieves the Contractor from responsibility as to material which may be rejected if found defective after delivery and must then be replaced by other material of the required quality without extra compensation.

PROTECTION

Steel reinforcement shall be protected at all times from mechanical injury, and, when placed in the work, shall be free from dirt, scale, dust, paint, oil or other foreign substance.

PLACING OF STEEL

The reinforcement shall be bent to the shapes indicated on the plans upon approved templates. Only competent men shall be employed for cutting and bending and proper appliances shall be provided for such work.

FASTENINGS

All bars shall be as long as may conveniently be used, of proper form and accurately placed and spaced. The joints in the reinforcement shall be as shown on the plans or as directed by the Engineer, and all such reinforcement shall be securely held in proper position by approved devices until the concrete shall have been placed.

LAPS

The laps in the reinforcement not shown on the plans shall have a length of not less than fifty (50) times the nominal diameter of the reinforcement, and shall be well distributed or concentrated in the shear regions.

ORDER LIST

Before ordering, the Contractor shall have order lists for all reinforcing steel approved by the Engineer.

Wing walls and abutments shall be thoroughly tied together with a sufficient amount of steel in both the plain and reinforced types of construction.

There shall be at least two inches clearance between the parapet wall and the edges of the shoes or bearing plates.

SPECIFICATIONS

(Special to this Contract)

For constructing a crossing over the.....
River and adjoining railroad tracks at.....
(Annexed to Contract No.....)

LOCATION

The bridges referred to herein are located in.....
County, Oregon, spanning the.....River
and adjacent railroad tracks at.....

SCOPE OF WORK

The work to be done includes the materials, erection and painting of one steel span with an alernate in wood, 180 feet long, together with concrete piers and wood pile approaches and a reinforced concrete viaduct over the railroad tracks.

CONTRACT DRAWINGS

No. 383 Profile and alignment.
No. 384 Approaches.
No. 385 Piers for 180 feet wood span.
No. 386 Reinforced concrete viaduct over tracks.
No. 387 Wooden span 180 feet.
No. 388 Details of wooden span.
No. 389 Steel span 180 feet.
No. 394 Standard wooden bents.

FLOORS

The timber work in connection with the span shall conform to the specifications for the same. Joists shall lap by each other at least the width of the floor beam flanges, and shall be S1E. Decks shall be well spiked with 7-inch spikes, laid heart side down, and shall be S1S. The two outside lines of joists shall be butt-joined. A double row of 3x4 inch bridging shall be placed at each panel point. Hand rail material shall be S4S and of sizes and dimensions shown on drawings. No members of the hand rail or hubguards to be spliced except at posts.

APPROACHES

The approaches are wood pile bents on the west side of the.....River, as shown on drawings Nos. 383, 384, and 394, with a penetration of 15 feet called for on the drawings. This penetration may be changed to suit conditions later found to exist, at the discretion of the Engineer, and according to the provisions of the proposals made a part of the contract.

PROPOSED BRIDGE SITE—DESCHUTES RIVER AT MOODY, COLUMBIA HIGHWAY Photo No. 11

OLD TOLL BRIDGE OVER DESCHUTES RIVER AT MOODY—NEW BRIDGE SITE JUST BELOW Photo No. 12

BRIDGE LEGISLATION IN OTHER STATES

From an investigation of the road and bridge laws of all the states it appears that only four—Georgia, South Carolina, Texas and Indiana—have no organized highway commission, Mississippi being the latest to come into line through act of the legislature of 1916.

The Federal Government could give no stronger proof of its belief in the advantages of road making under state supervision than the fact that there has recently been passed a Federal law involving in the next five years the expenditure of $85,000,000.00 by the United States in cooperation with the various states.

The examination of the state laws shows that:

1. In fifteen states plans and specifications for strictly county bridges **are prepared by** the State **on request** from the counties.

2. In five these plans and specifications prepared by the state are **obligatory** on the counties.

3. In six states plans and specifications (county) **may** be submitted to the state for **approval** at the option of the counties.

4. In eight states they **must** be submitted to the state for **approval** before any further action is taken.

5. In four states the plans and specifications for county bridges are drawn up by the counties, following **standards prescribed by the state** which are furnished the county for reference and permanent file.

6. In one state, Illinois, the **loading** of all county bridges is prescribed by law.

7. In seven states the county has absolute control over its bridges in all respects.

8. In eighteen states the state draws up plans and specifications for state aid roads only, the strictly county roads in those states being under county control.

9. Minnesota law **demands** the annual inspection of **all** bridges by the commission.

10. In Pennsylvania a complete road survey of each county is required to be furnished the commission by the county.

11. In South Dakota a charge is made for engineering services of the state rendered counties.

REMARKS

In those states—Iowa, Wisconsin, Illinois and New York—which have gone farthest toward an efficient concentration of duties in the hands of the state, the best results appear to have been obtained and the greatest service rendered for the money expended.

The foregoing data shows, as nothing else could, how widespread has been the attempt to get bridge building in the counties on a proper basis, and also to what an encouraging extent this end has been attained.

BRIDGE SITUATION SUMMARIZED

The experience of all states, as a result of their investigations, developed the following main and uncontrovertible features:

1. Lack of skilled supervision has been the cause of most of the bridge shortcomings.

2. County commissioners, as a rule, are the first to admit that they do not have the detailed technical knowledge necessary for securing the best results in connection with this work.

3. This lack of technical knowledge has caused county commissioners to purchase bridges by the yard or the foot, without regard to suitability.

4. Bridge companies, being in the business of selling steel, furnish more or less than necessary, depending upon whether or not it is to their advantage.

5. It is not claimed that such companies object to furnishing bridges that are properly designed, but as they have no specifications on which to bid, in order to make the lowest bid and secure the contract, they will naturally submit for consideration the lightest form of construction which it is believed will hold up under ordinary traffic, taking a chance on any extraordinary load which sooner or later it will have to bear.

6. Or an agreement to divide the territory leaves such companies free to draw up their own specifications and plans (left to them by the commissioners). The bridge furnished is accordingly unnecessarily heavy, if the price quoted is per ton of steel. Payment is usually made without measuring and counting the various members and computing the weight. Bridges are being purchased today by county courts in violation of law, without competition or proper advertising.

7. The excessive cost of bridges is due, among other things, to the following reasons:

   (a) Too long a bridge.
   (b) Type unsuited to location.
   (c) Competition restricted through various agencies and in various ways, such as posting a notice in the courthouse a few hours before the letting of contracts, or by failure to advertise.

8. Through the preparation or approval of definite plans and specifications of bridges by the State, and through

advertising in technical papers outside the county, much money has been saved to the counties.

9. Bridge companies in bidding upon such plans often find it unnecessary to visit the site, and consequently make a lower bid to such extent.

10. Bridge companies, bidding on exactly the same basis, and knowing exactly what they are to furnish, make a lower price.

11. Wider publicity makes it correspondingly more difficult for local contractors to pool their interests and raise prices.

VALUE OF DISINTERESTED ENGINEERING SERVICE

Many of the states require the approval of all plans and specifications for county bridges by the state highway department. The approval of this department is also required for final acceptance of the work. The plans and specifications may, however, be drawn up either by the highway department, the bridge contractors or by private consulting engineers.

1. Under such laws control is had by one central body with authority and skill to gradually bring about a standardization of plans architecturally and structurally.

2. A safe construction is assured which will meet not only loadings which are common at the time contracts are let, but other greater loadings which will become inevitable to meet growing traffic demands, within the life of the bridge.

3. An economy in cost will be possible through a knowledge of values which will enable the counties to protect themselves against unduly high prices of pooled bidders.

4. Counties will be saved from the error of purchasing bridges so flimsy that in them there is neither economy of maintenance nor safety to property or life;

5. And whose absolute cost over the term of years of their life, if they are passable at all to modern traffic, far exceeds the total cost of a high class bridge—basing the estimates on first cost, maintenance, depreciation and interest.

6. On the other hand the counties will not then commit the error of buying bridges unnecessarily heavy and of uneconomical design, such as are found in certain parts of the State. Some are of extravagant design for the localities where they are built. Others contain an excessive amount of material and would be of uneconomical design anywhere.

7. By the system of bridge construction advocated and by reason of the services rendered gratis by the department, to which attention has been directed in this Manual, it is

confidently expected that the cost to the counties for the more modern structures will be but little if any greater than for poorer structures of similar span in the past, and most certainly many of the defects in both superstructures and foundation work will be remedied.

CONCLUSION

It is hoped that this Manual may be of some service to the various counties in bringing about greater uniformity in practice and methods of construction.

BULLETINS OF THE STATE HIGHWAY COMMISSION

Prepared under the direction of John H. Lewis,
State Engineer, Salem, Oregon.

Bulletin No. 1—"Outline of the Road Laws of Oregon." Presents, under appropriate heads, all of the law dealing with each subject for the assistance of those desiring to improve the same, and to assist public officials in the administration of this law.

Bulletin No. 2—"Manual of Accounting." Contains forms and details of the cost-keeping and accounting system adopted by the State Highway Department, and issued for the guidance of employes. Is available to counties who wish to install such system.

Bulletin No. 3—"Bridge Manual." Contains standard plans and specifications for bridges, culverts and retaining walls; also instructions for designing, erecting, inspecting and maintaining bridges. Furnishes information to county courts as to what and how information can be had free of charge from the State Highway Department under present law.

Bulletin No. 4—"Manual of Field and Office Practice." Contains detailed instructions for handling vouchers and accounts; purchasing and accounting for property; instructions for making surveys, preparing plans, etc. Issued in mimeograph form April, 1916; to be revised and printed for distribution early in 1917.

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